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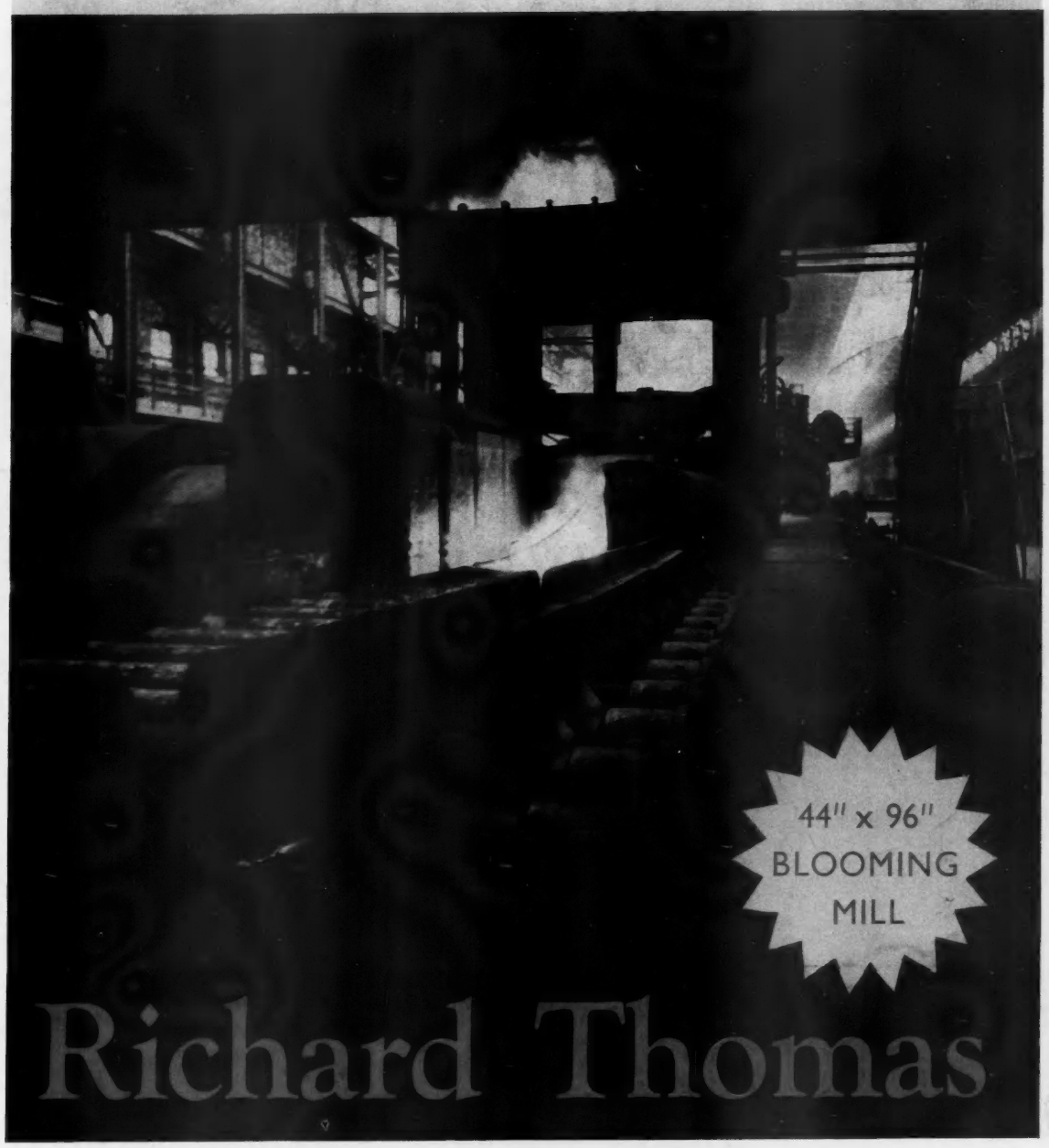
HIGH GRADE STEEL SHEETS: STEEL STRIP: TIN-PLATES



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A Seven-Day Journal

The Machine Tools Week Appeal

In a leading article which appeared in our issue of November 8th, we recorded the inauguration of a Machine Tools Week on Monday, November 4th, by Mr. Harold MacMillan, Parliamentary Secretary to the Ministry of Supply and Chairman of the Industrial Capacity Committee, and Mr. P. H. Mills, the Controller of Machine Tools. As a result of the appeal many more machines, the Ministry of Supply states, will be fully engaged on war work. Among the replies which have been received, some, it is stated, were indicative of the splendid spirit of sacrifice of the British people. Treasured old lathes, hand-driven machines, that could not possibly be adapted to the requirements of the machine shop of to-day, and tools that are not machine tools at all, have been offered to the Controller, in the hope that they would be of service in munition factories, as well as many valuable tools not now in full use. On Wednesday, November 13th, a further letter, signed by Mr. Mills, the Controller of Machine Tools, was sent to 120,000 firms of all kinds, so that nothing which can be used in the national effort shall escape the survey. In spite of the appeal which was made three months ago for the voluntary release of all machine tools not fully employed, large numbers are still required. These include, it is stated, machines such as capstans, turrets, milling and horizontal boring machines for the production of aircraft components, centre lathes for bomb and sheet making, and heavy machine tools for tank and shipbuilding. Thousands of other machines of all types are also required by the Ministry of Labour for the very necessary training of operatives on which the supply of skilled labour depends. Mr. Mills concludes his appeal by asking factory owners to offer all the machines which they can make available to used machine tool dealers operating under licence from the Ministry of Supply or to the Controller himself. Arrangements for inspection and distribution will be made with prompt payment for the machines released.

Shipyard Wages

Representatives of the Shipbuilding Employers' Federation and of the Confederation of Shipbuilding and Engineering Unions met in resumed wages conference at the Crown and Mitre Hotel, Carlisle, on Friday last, November 15th, in order to give further consideration to the application submitted by the unions for a general wages advance of 10s. per week to plain time workers, with a corresponding advance to piece workers. Mr. H. Main, the President of the Employers' Federation, speaking at the conference, replied to the case which had been presented by Mr. J. W. Stephenson, the President of the Confederation of Unions, at the earlier conference held on September 20th, in support of the application. In the course of the reply, Mr. Main explained that the conclusion, which had been reached after very careful consideration of the full case made by the unions, was that the Federation did not feel there had been any change in circumstances since the 5s. war bonus advance was given in February of this year which would justify or should necessitate any further increase in wages at the present time. Mr. Stephenson, on behalf of the unions, said they were disappointed with the industry's reply to their application, and that the unions would now require to report the position for consideration by a meeting of the executives of the Confederation of Unions, which took place at York on Wednesday last, November 20th.

The Fleet Air Arm Attack on Taranto

On Wednesday, November 13th, the Prime Minister announced in the House of Commons that the Royal Navy had struck a crippling blow at the Italian fleet. The total strength of the Italian battle fleet was six ships, two battleships of the "Littorio" class, just put into service, and four of the recently reconstructed "Cavour" class. On the night of November 11–12th, when the main units of the Italian fleet were lying behind their shore defences in the naval base at Taranto, our aircraft of the Fleet Air Arm attacked them in their stronghold. It was established, Mr. Churchill announced, that one battleship of the "Littorio" class was so badly down by the bows that her forecastle is under water and she has a heavy list to starboard. One battleship of the "Cavour" class has been beached and her stern up to and including the after turret is under water. The ship is also heavily listed to starboard. It also appears probable that a second battleship of the "Cavour" class has been severely damaged and beached. In the inner harbour of Taranto two Italian cruisers are listed to starboard and are surrounded with oil fuel and two fleet auxiliaries are lying with their sterns under water. On November 15th an Admiralty communique stated that a further reconnaissance of the Italian base at Taranto had established with certainty that three battleships were cripp'ed during the Fleet Air Arm attack. Efforts are being made to salvage the battleship of the "Littorio" class and the bows of the ship has been raised and she now has a list to port. The reconnaissance also confirmed that two battleships of the "Cavour" class are aground. One is beached and the second has been, it appears, abandoned. She is lying heeled over to starboard, with only the forepart of her upper works above water. It was also reported that four shapes can be seen under water off the entrance to the graving dock in the inner harbour. On the night of November 11–12th a squadron of our light naval forces, operating on the main line of the Italian communications between Italy and Albania, intercepted off the Albanian port of Valona an enemy convoy consisting of four supply ships escorted by two destroyers. One of the supply ships was sunk outright, two were set on fire and almost certainly sank, and the fourth was damaged and escaped under smoke screen. Both destroyers escaped at high speed under cover of smoke, but one of them was hit and damaged. No damage or casualties were sustained by our naval forces. In the Fleet Air Arm attack, which was carried out in the face of strong anti-aircraft defences and a balloon barrage, only two aircraft were lost.

The Fuel Research Board Report

The Department of Scientific and Industrial Research has just issued, through the Stationery Office, the Report of the Fuel Research Board for the year ended March 31st, 1939. It gives a comprehensive review of the work carried out for the Board during the year, including the latest progress in the survey of the coal resources of this country. The survey is one of the main functions of the Fuel Research Board and covers fifteen great coal-bearing areas. Problems under investigation include the intentional breaking of large coal to popular sizes, the accidental breakage of coal caused by handling, transport and storage, the deterioration of coal by weathering, the cleaning of fine coal and the "dust-proofing" of coal. The carbonisation of coal has many aspects, and the Fuel Research Station is able to suggest how the fluctuating market conditions may be met by using a wider range of coals. This has in some instances taken the form of making the carbonisation process more flexible. Hydrogenation is now widely known to the general public because, when applied to coal, coal tar and oils, it can produce aviation and motor spirit, diesel fuel and even lubricating oil. Research work in progress includes the hydrogenation of different raw materials, a study of catalysts, and the "cracking" of oils. Motor spirit and diesel oil may also be produced by catalytic synthesis from carbon monoxide and hydrogen, both of which may be derived from coal. Laboratory experiments and work on a plant of semi-technical scale are both described and further treatment of certain fractions of the primary product shows promise of yielding lubricating oil.

The Shipbuilding Employers' Federation

At the annual general meeting of the central board of the Shipbuilding Employers' Federation, held in Carlisle on November 15th, Mr. J. M. Ormston, the shipbuilding manager of Vickers-Armstrongs, Ltd., at Barrow-in-Furness, was elected President for the coming year, in succession to Mr. Henry Main, the managing director of the Caledon Shipbuilding and Engineering Company, Ltd., of Dundee. Mr. H. B. Robin Rowell, a director of R. and W. Hawthorn, Leslie and Co., Ltd., of Hebburn-on-Tyne, becomes the Senior Vice-President. Mr. Louis V. Dunlop, the general manager of Harland and Wolff's Govan shipbuilding yard, and Mr. Wilfrid Ayre, the chairman and managing director of the Burntisland Shipbuilding Company, Ltd., were also appointed Vice-Presidents. Mr. G. R. Green, of Silley, Cox and Co., Ltd., of Falmouth, was elected Chairman of the Conference and Works Board, with Mr. A. L. Cochrane, a director of Cochrane and Sons, Ltd., of Selby, as Vice-Chairman.

The Loss of H.M.S. "Jervis Bay"

On November 5th a convoy of thirty-eight ships, one of which had dropped astern, was attacked by a powerful German raider, probably an armoured ship of the "Deutschland" class. The convoy was under the escort of the armed merchant cruiser H.M.S. "Jervis Bay," under the command of Acting Captain E. S. F. Fegen, R.N. That over three-quarters of this large convoy escaped destruction, thirty-two ships to date, was due to the high efficiency of the captains of the merchant vessels in scattering and making use of smoke, and to the very gallant action of the "Jervis Bay." As soon as the convoy was attacked, H.M.S. "Jervis Bay" steered for the enemy while the merchant ships were taking avoiding action under cover of smoke. She continued to steer towards the raider, although she was completely outranged by the much heavier armament of the enemy, thus drawing the fire of the enemy away from the ships in convoy. Very early in the action H.M.S. "Jervis Bay" was heavily hit, and although partly out of control and seriously on fire she continued to hold the enemy fire while the ships of the convoy were making good their escape. For nearly an hour the armed merchant cruiser was continually hit by enemy gunfire, during which time she was engaging hotly, in an attempt to divert the enemy gunfire from the convoy. She subsequently sank about three hours after the raiding ship was first sighted. One of the ships of the convoy, a Swedish vessel, went back and was able to take on board sixty-five survivors of H.M.S. "Jervis Bay," who were safely landed in Canada. According to the Admiralty communique of November 15th, as far as can be ascertained, four ships of the convoy only, having a total tonnage of 25,453, were sunk by the raider, another ship of 7900 tons being still unaccounted for. The thirty-eighth ship, one of 2374 tons, which escaped from the raider, was subsequently attacked by aircraft three days later and was set on fire and abandoned. On Saturday, November 16th, it was announced that the King has been graciously pleased to approve the award of the Victoria Cross to the late Commander (Acting Captain) of H.M.S. "Jervis Bay," Edward Stephen Fogarty Fegen, Royal Navy, for valour in challenging hopeless odds, and giving his life to save the many ships it was his duty to protect.

Refrigeration Insulation Manufacturers Association

It is announced that a new association, under the title of the Refrigeration Insulation Manufacturers' Association (short, R.I.M.A.), has been formed with the object of promoting, encouraging, fostering, developing, and protecting the business in commercial refrigeration, insulation, and kindred insulated products, and, in particular, the interests therein of the members of the new Association. The Association will also establish and maintain fair and reasonable conditions of sale and distribution, and will promote and encourage propaganda. It will act generally with other kindred bodies and in particular the Commercial Electric Refrigeration Association (or the C.E.R.A.) in furthering the objects of the Association. The new Association is affiliated to the British Electrical and Allied Manufacturers' Association and its membership is open to all approved manufacturers in Great Britain of insulation for thermal control who are willing to abide by the Association's constitution, rules, schedules, and decisions made collectively from time to time. It is the desire of the newly formed Association to make it a body which will be as fully representative of the insulation industry as possible. It is requested that members of the trade who are interested in this matter should communicate as soon as possible with the secretary of the Refrigeration Insulation Manufacturers' Association, Mr. Felix A. Rogers, at the address of the Association, Kern House, Kingsway, London, W.C.2 (telephone, Holborn 0502).

Economy in the Use of Cement

A brochure which has just been compiled by the Director of Building Research, and is published by the Department of Scientific and Industrial Research, invites economy in the use of cement. A very extensive programme, it reminds us, is being pushed through on Government account, which is equally important in all of its sections and which is making very heavy demands on the productive capacity of the cement industry. There is very little between the various sections of the programme in order of urgency, and the extravagant use of cement on one job means very definitely that other work will be held up. A very definite responsibility, it is stated, rests upon those engaged on building works to see that cement is not used except where necessary. Where concrete must be used, it is essential that it should be used in the most economical way. Tarmacadam may be used instead of concrete for roadways, pavings and runways. In all cases where cement is utilised in large quantities, such as in the construction of roadways, aeroplane runways and aprons to hangars, floors to factories and buildings and foundations, it is very necessary to see that cement is not wasted by mixes too rich or concrete slabs too thick. As an illustration of the sort of economy which can be obtained a case is cited where, following pre-war practice, a factory had reinforced concrete floors 6in. thick in a 1 : 2 : 4 mix. By substituting a 5in. thickness in a 1 : 6 mix a sufficient quantity of cement could have been saved to provide air raid shelter for as many as 16,000 persons. The brochure is drawn up in such a way that it appeals to the bricklayer, the plasterer and the concreter. The subject is dealt with at greater length in Building Research War-time Bulletin No. 9, published by the Stationery Office.

High Precision Gauging

No. 1

ACCURATE gauging and measurement is always a factor of great importance in most branches of engineering, but in these days of stress it has assumed a significance in the scheme of national production far beyond its peace-time status. We have therefore felt that it would be desirable to lay before our readers some information concerning the design and operation of recent gauging and measuring equipment intended for use in workshops rather than in laboratories. In selecting the items for inclusion in this short series of articles, we have perhaps interpreted its title somewhat liberally, and have included in it descriptions of equipment which hardly seem to fall under the heading of gauges, as that term is commonly used. Nevertheless, it is hoped that the inclusion of a few references to devices and equipment which, although not strictly speaking gauges, do at least serve a similar purpose in that they promote accuracy of manufacture, will be found helpful to our readers. The series does not pretend to be exhaustive. Difficulties natural to the times have prevented us from collecting a considerable amount of information concerning equipment which we are well aware ought to have been mentioned in the articles which follow. It is, however, hoped that any of our readers who have information on this subject which is not included in the series will communicate it to us, in order that we may be able to supplement the articles as occasion may serve.

Alignment Telescope

It is frequently necessary to align a pair or a series of widely separated bearings and to ensure that their axes are not only parallel but coincident. This problem occurs in many branches of engineering, such as the building of marine and diesel engines, turbines, shipbuilding, and aircraft construction. The assembly jigs used in the mass production of aircraft are frequently of considerable length, and during the course of erection the large end pillars and other supports must be set and fastened in correct relation to one another. As the separation between these components increases, the accuracy of mechanical measurements, such as trammelling, rapidly becomes lower. Considerable time and labour must be expended in making

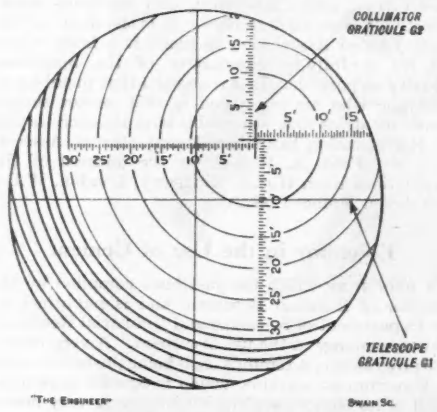


FIG. 1—TILT MEASUREMENT

measurements over such a long span, and this work must be repeated every time the jig is inspected.

Optical alignment measurements and settings by means of an alignment telescope, made by Taylor, Taylor and Hobson, Ltd., of Leicester, represent a considerable saving in time in erecting and inspecting these jigs, and, when once the necessary holding fixtures have been attached to the jigs, the optical equipment can be placed in position, measurements made, and adjustments effected in as many minutes as the mechanical method took hours. The alignment telescope enables measurements to be made of the displacement between the axes of a pair of bearings and the relative inclination (tilt) between them. It consists of a telescope for purposes of observation and a collimator unit in which are the target scales for measuring the tilt and displacement of the axes relatively to one another. These two units take the form of hardened and accurately ground steel cylinders which house the optical elements. Their walls are thick to withstand firm clamping and their length, in proportion to their diameter, ensures accurate location relatively to the bearings under test. The diameter of the telescope and collimator tubes is 2·2495in. to 2·2498in., and special precautions are taken in manufacture to see that the optic axis of the unit corresponds with its mechanical axis, and that the diameter is held constant along its length.

When the instrument is set up to test the alignment of a pair of bearings, the telescope can be focused on either of the two target scales in the collimator unit. These scales, in conjunction with the cross lines which can be seen simultaneously in the telescope, enable direct readings to be made either of the relative tilt between the axis of the telescope and collimator or the displacement between those axes.

Tilt measurements are read off directly in minutes of arc, and can be made in two meridians at right angles (generally vertical and horizontal) in the manner shown in Fig. 1. Displacements between the axes are measured as shown in Fig. 2, in which direct readings are made where the telescope cross lines cut the scales. Owing to the fact that the size of the scale divisions, as seen in the telescope, becomes less as the distance between the telescope and target increases, a series of scales is provided which show intervals of 0·010in., 0·020in., and 0·050in. Thus at close separations (say, 5ft. to 10ft.), the 0·010in. graduations are easily visible

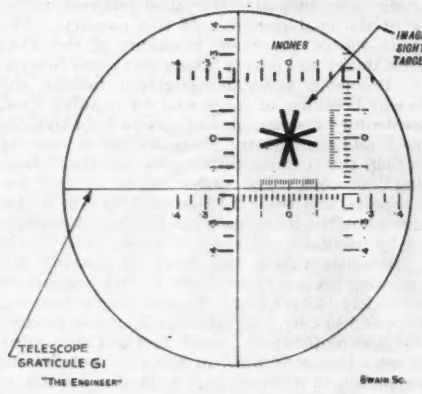


FIG. 2—DISPLACEMENT MEASUREMENT

and capable of subdivision by virtue of the magnification provided by the telescope. As the distance increases the 0·020in. or 0·050in. divisions must be used because the 0·010in. intervals become too small to be clearly visible. Hence it will be seen that the reading accuracy of the instrument, when making displacement measurements, is dependent on the distance over which those measurements are made. Tilt measurements, however, are independent of the separation, since the scale is virtually at infinity and consequently its image always appears the same size. The accuracy of the instrument, under normal working conditions, enables measurements of displacement to 0·010in. at 50ft. to be made and tilt to be measured to 6 sec. of arc (1 part in 30,000).

By means of the star in the centre of the target scale, it is possible to make alignment settings as distinct from measurements, to a much higher standard of accuracy. This involves moving one or other of the units (telescope or collimator) until the cross lines in the telescope are set exactly in the middle of the vees which make up the central star on the target. A lack of alignment too small to be read on the scale is easily visible in this way because the telescope cross lines will cut one side of the vee instead of splitting it exactly at the apex.

When a succession of bearings has to be aligned, the displacement scale may be used alone, mounted in a circular steel frame called a target plug. These plugs have a diameter of 1·4990in. to 1·4995in., and the central star of the scale lies accurately in the centre of the steel plug. A target plug can be fitted into each bearing, the speed of working being thereby much increased.

The mechanical construction of the alignment telescope makes it readily adaptable to many alignment problems, but for each different application suitable provision must be made for holding the optical units in correct and known relation to the axes which it is desired to align. The holding fixtures may take the form of vee blocks of some kind when the instrument is used for setting up and checking air frame jigs. Bearings will require an accurately constructed jacket which holds the optical unit centrally in the bearing. An interesting application is to the levelling of the beds of large machine tools, as, for example, a planer. The collimator and telescope are supported on the bed on vee blocks and the straightness of the ways is measured by reading the lack of alignment in different places on the bed. A test of parallelism between the two units must be made by focusing on the tilt scale, after which displacement readings can be taken. Those parts of the bed which are out of line can be adjusted by means of wedges between the bed and its foundation until the central star of the displacement scale is accurately in register with the telescope crosslines. Such is the accuracy of this setting that a bed can be levelled to about ±0·001in. over a length of 30ft.

The Dynamic Balancing of Rotors

Apparatus which indicates the phase and extent of unbalance of a rotor has been produced by Ferranti, Ltd., of Hollinwood, Lancs, in which correction is made in two axially separated planes. The correction is made either by the removal of material or by the addition of weights. In the first case the material may be specially provided on the rotor, but in most cases this is not necessary, as the amount removed is slight if the rotor has been carefully designed.

The apparatus is provided with either two blocks

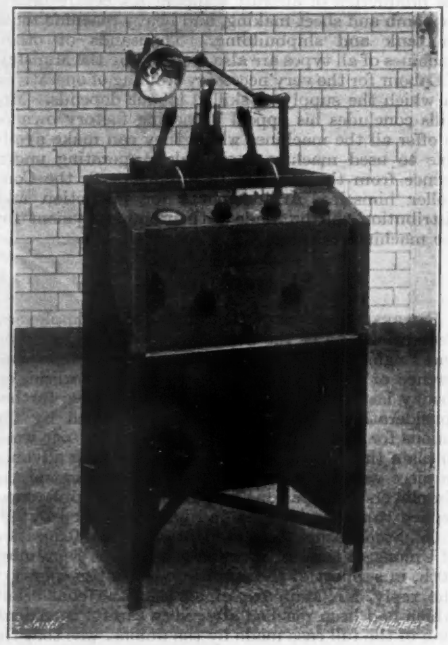


FIG. 3—APPARATUS FOR DYNAMIC BALANCING OF ROTORS—FERRANTI

of lignum vitæ, having well-oiled vee-shaped grooves at the top for taking a rotor spindle or with other suitable fittings, *e.g.*, for taking a ball race. Figs. 3 and 4 show a machine fitted with aluminium blocks for this latter purpose. These fittings are mounted in line on ash springs, their alignment being assured by adjusting screws. The ash springs are carried by a base-plate standing on a sponge rubber cushion and any vibrations set up in them are damped by rubber blocks which in certain conditions are soaked in oil. The rotor under test is mounted in the fittings and a light belt driven over a pulley by a synchronous motor running at a suitable speed is arranged to be moved into contact with or away from the surface of the rotor. Steel rods are let into sponge rubber bushes in the fittings parallel with the spindle of the rotor, and each rod is connected to a gramophone pick-up movement.

Oscillations from the pick-ups provide a means of measuring the phase and extent of the out-of-balance of the ends of the rotor adjacent to the pick-ups. Since, however, out-of-balance of one end of the rotor may give vibration to the pick-up near the other end, any oscillation of this latter pick-up must be subtracted from that due to the pick-up near the end under test. A mixer circuit embodying an arrangement of cross-over connections and a two-way switch enables the oscillations of either pick-up less those due to the other to be applied to a measuring circuit.

This circuit consists of a calibrated potentiometer connected to a thermionic valve amplifier having a tuned circuit connected to its anode,

resonant according to the speed of rotation of the rotor for correct phase indication and for the elimination of unwanted vibration components. The output of the amplifier valve is fed by way of a pulse generating valve to a stroboscopic lamp, arranged to illuminate a marked part of the rotor under test. By suitable tuning of the resonant circuit when the instrument is initially set up, the heavy part of the rotor may be caused to be always at a predetermined position, *e.g.*, the top, when the marked part appears to be stationary during the course of a test.

A valve voltmeter is provided to measure the amplitude of the oscillations and the extent of out-of-balance is shown by the setting of the calibrated potentiometer required to produce a predetermined reading on the voltmeter. The rotor is

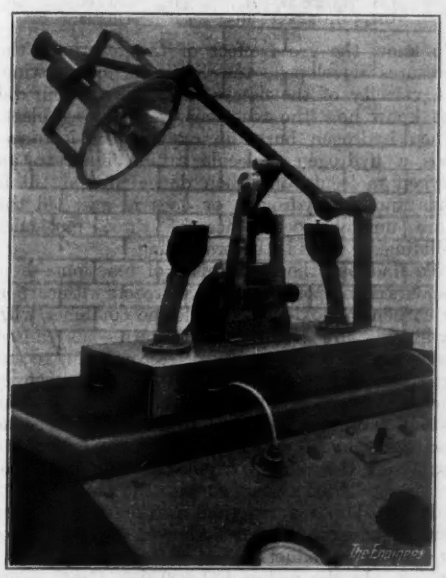


FIG. 4—DETAIL OF DYNAMIC BALANCER

then removed and small quantities of material ground from the heavy part, the amount being determined by experience, having regard to the reading of the potentiometer.

The same procedure is carried out for the other end of the rotor, the switch being changed over. The process is repeated for each end alternately until perfect balance within the range of the measuring apparatus is obtained. The average time taken for a small-sized rotor is about 10 min. The apparatus is therefore well adapted as an instrument of high precision for use in mass production.

"ELECTROLIMIT" GAUGES

The "Electrolimit" gauge principle, developed by Taylor, Taylor and Hobson, Ltd., of Leicester, is claimed to be capable of wide application and has been adapted to the production of comparators for external and internal measurements, continuous gauging of sheets, and measuring the thickness of plating layers. In essence, the gauge depends for its action upon mechanical contact, the movement of which is amplified electrically. One outstanding feature of this combination is that the magnification is variable; the gauge is also very robust but sensitive.

In all its forms the "Electrolimit" gauge consists of four main units—the electric head with mechanism for making contact with the work, the power unit, the indicating micro-ammeter, and the stand for supporting the electric head carrying the contacting mechanism in contact with the work. The working principle is that of a balanced A.C. bridge of four inductance coils. Two of these coils are built into the electric head and have between them a steel armature coupled to the gauging spindle. The bridge circuit is balanced to give zero meter reading when the armature lies midway between the coils in the electric head; a displacement of the armature, due to the movement of the gauging spindle, upsets the balance of the bridge circuit. This causes current to flow through the micro-ammeter, the amount of which is in proportion to the displacement of the armature. The sensitivity of the circuit is governed by the separation of the coils from the armature. Hence when the coils are adjusted so as to be close to the armature, the magnification is high; as the coils are separated from the armature the magnification decreases. This adjustment is described below.

In Fig. 5 we illustrate the electric head of the external "Electrolimit" gauge. As will be seen the armature A, hinged at one end, lies between the two inductance coils T_1 and T_2, adjusting screws being provided for altering the separation of these coils from the armature. The gauging spindle S, the lower end of which is diamond tipped, makes contact with the work, and movements of this spindle are communicated to the armature. Displacements of the armature are electrically amplified and indicated on the micro-ammeter scale. Fig. 6 shows the external "Electrolimit" gauge, the principal components of which can

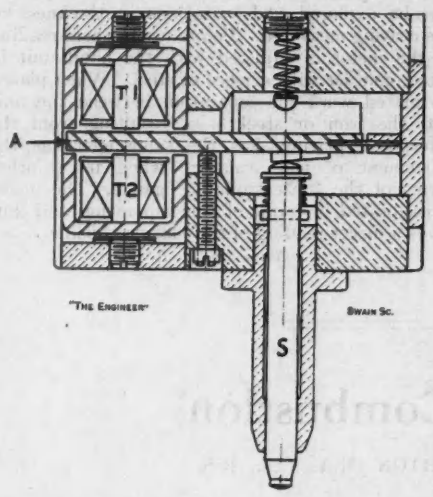


FIG. 5—ELECTRIC HEAD OF "ELECTROLIMIT" GAUGE

easily be recognised. Provision is made for fine adjustment of the magnification, using a knob in the base of the gauge; coarse and fine adjustments for the zero setting are also provided in the electric head and gauge base respectively.

Magnification is adjusted in accordance with the tolerance allowed on the work being inspected. This is set as a rule by means of standard slip gauges. The method adopted is to choose three slips (for maximum, zero, and minimum), of which the maximum difference is to represent the proposed full-scale reading of the meter, and place

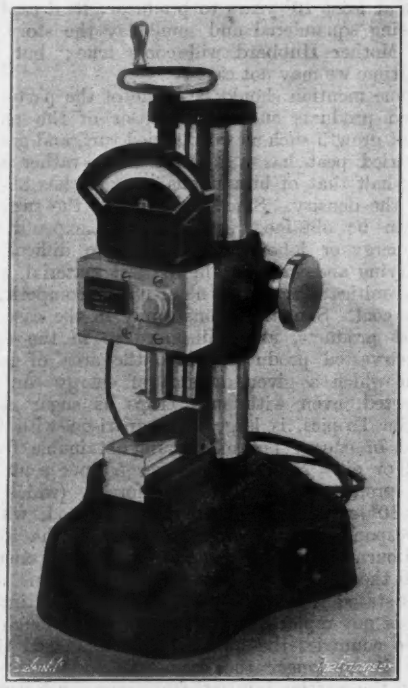


FIG. 6—"ELECTROLIMIT" EXTERNAL GAUGE—TAYLOR, TAYLOR

them side by side on the gauge anvil. With the intermediate (zero) block under the gauging spindle, the gauge head is raised or lowered sufficiently to bring the pointer on to the zero mark and set exactly by means of the zero adjustments. The other two slips are then placed in turn on the anvil under the gauging point and the positions of the coils progressively adjusted (either towards or away from the armature) until the magnification is such that the larger slip gives the maximum scale reading while the smaller block gives the minimum reading. An alternative method of making the magnification setting would be to take three workpieces representing the maximum and minimum tolerable sizes and the correct (zero) size and use these instead of gauge blocks.

The micrometer usually has a scale length of 3¼in.; by varying the magnification this can be made equivalent to a displacement of the gauging point ranging from 0·00025in. to 0·004in. Thus, at the highest magnification, where 0·00025in. is magnified to a pointer movement of 3¼in., a scale division of such easily visible size as $\frac{1}{16}$in. will be equivalent to approximately 0·000005in. Set to its least sensitive condition, the same size scale division would be equivalent to 0·00008in.

A variation of the "Electrolimit" gauge is the model for measuring internal diameters illustrated in Fig. 7. This gauge utilises a spindle to act as a plug member for the hole to be measured. A pressure shoe arrangement pulls the work on to a pair of tungsten carbide inserts, the edges of which are formed into a suitable radius proportionate to the diameter of the hole to be gauged, thus forming two lines of contact between the

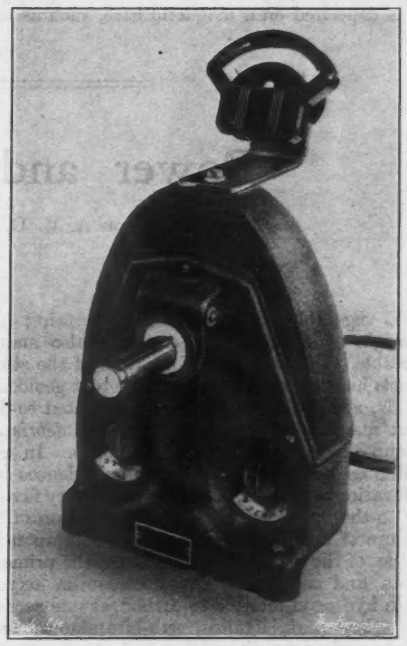


FIG. 7—INTERNAL "ELECTROLIMIT" GAUGE—TAYLOR, TAYLOR

work and the spindle. The gauging point makes contact with the work opposite the tungsten carbide strips and the whole assembly forms a three-point gauging system. By turning the work on the spindle lack of roundness can be detected and measured, whilst moving the work backwards and forwards along the spindle shows up lack of straightness of the hole. By means of suitable spindles, holes upwards of ½in. diameter can be measured.

The gauge is made in two main models. Fig. 7 shows the bench form in which the work is offered to the gauge. This form is suitable for light, easily handled parts. For heavier work the plug element must be presented to the work, and, for this purpose, special hand units have been developed which embody the plug and also the electric head. The indicating meter and power unit are connected to the hand unit by means of a flexible cable.

The internal gauges must be adjusted by means of suitable master ring gauges. Their magnification can be altered in a manner similar to that of the external model; but they are meant essentially for production inspection, since a special plug element is required for every hole to be gauged. They are very suitable for the inspection of mass-produced work which must be held to close limits and enable components to be graded for selective assembly. Successful applications have been found to many gauging problems, notably in the manufacture of aeroplane engines, for example, in the measurement of cylinder bores, connecting-rod bearings, and gudgeon pin holes in pistons.

A special type of "Electrolimit" gauge has been developed for measuring continuously the thickness of sheet materials as they travel through the rolling mills. The measuring unit is arranged on a slide so that it can travel across the sheet in order to measure the thickness at any point on its width. Special attention is paid to the design of the measuring device which must be robust

enough to withstand the heavy vibration and rough handling to which it is subject. At the same time, the gauge will stand up to a hot, steam-saturated atmosphere and will work efficiently without attention even under a stream of water.

The moving sheet from the mill passes between a pair of spring-loaded contact rollers, one of which is linked to the armature in the electric head of an "Electrolimit" gauge. Variations in the separation of the rollers, caused by changes in the thickness of the sheet between the rollers, are electrically magnified in a manner similar to that adopted in the internal and external gauges. The indicating meter is placed in some position where it can readily be kept under observation by the mill operator. In addition, a recording device can be made to trace on paper a continuous record of the variations in thickness of the sheet during the running of the mill.

It is frequently necessary to measure the thickness of a coating or plating on iron or steel. A special form of "Electrolimit" thickness gauge can be used for this purpose when the plating is non-ferro-magnetic, such as chromium or copper, and is deposited on a magnetic base, such as iron or steel. In the normal course of events it would be necessary to damage or even to destroy the sample in the course of measuring the thickness of the coating. The specimen has also to be prepared and the making of each individual measurement occupies some time. When using the "Electrolimit" thickness gauge it is only necessary to place the hand unit in contact with the sample wherever the thickness of the coating has to be measured and an instantaneous reading is obtained. As many readings can be taken as desired and just as quickly as the hand unit can be placed in the required position; hence the entire surface can be explored and variations in thickness of the coating measured. Before use the zero reading of the meter is adjusted with the hand unit in direct contact with a piece of steel. When placed on plated work the separation between the unit and the iron or steel base, resulting from the interposed plating, has the same effect as the movement of the armature when using other forms of the "Electrolimit" gauge. The meter is calibrated in terms of this separation and thus gives a direct reading of the plating thickness.

(To be continued)

Power and Combustion*

By Professor A. C. G. EGERTON, M.A., Sec., R.S.

Coal and Oil

THE vegetable origin of coal is certain; the origin of oil is almost certainly also mainly vegetable. The process of formation of the stores of fuels has gone on in most of the great geological periods, and it is no doubt being repeated to-day where masses of waterlogged vegetable *débris* are decomposing under bacterial influence. In carboniferous times when alternate subsidences and re-elevations occurred, conditions were very favourable to the formation of coal by the action of the pressure of the superincumbent deposits upon the residues of the luxuriant vegetation of the primeval forests and swamps. The decrease in oxygen and in hydrogen relative to carbon, as one ascends the series—peat, lignites, sub-bituminous, bituminous, and anthracite coals—indicates a common nature of the process of formation (Table I).

Table I.—*Results of Analysis of Typical Fuels*

	Carbon, per cent.	Ratio, carbon/ hydrogen.	Ratio, carbon/ oxygen.	Per cent. volatile substances.
Wood	50	8·3	1·18	75
Peat	60·3	11·0	1·87	65
Lignite	73	13·3	3·65	47
Sub-bituminous ...	75	12·5	4·52	45
Bituminous	84·7	16·6	10·6	33
Semi-bituminous ...	84	17·9	16·1	20
Anthracite	92	30·8	23·0	7

There is some similarity in the formation of petroleum, but it originates almost certainly from marine deposits rather than from forest swamps. The seashore muds, sands, and calcareous deposits contain organic matters enriched by algæ. In course of time these form the sedimentary clays and limestones, dolomites, and sandstones in which the oil is produced by some process, the nature of which is not perfectly known. If it can do so, the oil passes through the porous strata and collects when it reaches impervious rock.

Methane is always formed in the process of coal and oil formation, and "natural gas," which is often associated with petroleum, exists in vast quantities. Though estimates have been made to fair depths, there is no telling what is the complete extent of the vast stores of energy in the form of coal, oil, and carbonaceous shales, &c., neither is it easy to estimate from the known botanical and geological data the comparative rate of conversion of the solar energy into those stored products in the course of ages.

The world reserves of coal were estimated in 1913 down to 6000ft., and found to be between 7×10^{12} and 8×10^{12} tons, of which about 60 per cent. was anthracitic and bituminous. A better estimate has not yet been made and it should be taken as very elastic.

The following figures give some idea of the amount we rely on these stores of energy. Probably not much more than a thousand times the following quantities are easily available:—

Approximate World Use of Coal and Oil (1937)

	Tons per annum.
Coal	1450×10^6
Petroleum	276×10^6
Natural gas (calculated as CH_4) ...	55×10^6

Every year a mountain of coal, nearly as big in volume as Vesuvius, is burnt, and the consumption of oil is a river with a flow about equal to that of the Thames in summer. The rate at which coal is used does not vary much from year to year, whereas the use of petroleum increases constantly.

We are using up in 10^2 years what it probably took at least 10^7 years to produce. Real capital is being squandered and some day the story of Old Mother Hubbard will come true; but by that time we may not care![1]

Some mention should be made of the partially stored products such as peat, or of the more recent growth such as wood, dried turf, and grass. Air-dried peat has a calorific value rather less than half that of bituminous coal; it has about half the density. Since it occurs on the surface it can be obtained without much expenditure of energy or labour; but there are difficulties in drying and transport of the wet material, and these mitigate against general use in competition with coal. Similar reasons apply in the case of forest products, and still more so in the case of harvested products, where the area of land from which a given amount of energy can be collected, even with such crops as sugar cane in the Tropics, is large in comparison with the yield of energy per man-hours obtainable from coal or oil. Nevertheless, over 50 per cent. of the product of the world's forests (which is 56×10^9 cubic feet) is burnt as firewood, which corresponds to 0·16 of the energy of the total coal burnt. The inroads on the reservoir of energy that the forests represent are very serious and it is stated that 30 per cent. of the total timber cut is not replaced by new growth, although in some countries the forests are so managed that this is no longer the case. Taken the world over, the position is unsatisfactory; even Nature's recent stores are robbed faster than they are replaced.

Combustion

For a long time after Heraklitus, fire was looked on as an element; but Hooke (1665) first saw the truth when he described "that shining transient body which we call Flame" as "nothing else but a mixture of air and volatile sulphurous parts of dissoluble or combustible bodies which are acting upon each other whilst they ascend." Nowadays we should say: Fire is the maintenance of incandescence at the surface of a solid by the heat evolved in the combustion of gases generated at the surface, or (what is not quite the same thing) by the combustion of the surface atoms and their removal as gaseous products at high temperature. A flame is a gaseous mixture undergoing luminous combustion. A flame may contain solid particles raised to incandescence by the heat of the products of combustion, or there may be a "cool" flame, a chemi-luminiscent effect, occasioned by partial combustion.

For a long time we have known all about the products of combustion, and that they have such and such a composition, or the flame such and such a temperature, from data for the equilibria represented in such equations as:

$$C_s \rightleftarrows CO + \tfrac{1}{2}O_2; \qquad \Delta H_{298^\circ} = 67{,}623$$
$$H_2O \rightleftarrows H_2 + \tfrac{1}{2}O_2; \qquad \Delta H_{298} = 57{,}809$$
$$CO + H_2O \rightleftarrows CO_2 + H_2; \qquad -\Delta H_{298^\circ} = 9{,}814$$
$$CH_4 + H_2O \rightleftarrows CO + 3H_2; \qquad \Delta H_{298^\circ} = 49{,}268$$

We knew the gross effect of the reactions, the pressures developed, the limits of combustion, the velocity of the flames, &c., but we still did not know how the reactions were taking place. When hydrogen burns in oxygen, for instance, does a hydrogen molecule attach itself to an oxygen molecule and then dance around till it finds another hydrogen, or does it wait till the more unlikely occurrence of three molecules colliding, or what is the proceeding?

To find out the mechanism of reactions—how vapours decompose, how oxygen reacts with carbon or carbon monoxide, how chlorine combines with hydrogen, how hydro-carbons burn—has caused much activity in chemical research in recent years. If we cannot unravel the mechanism of such reactions as the oxidation of carbon, the oxidation of hydrogen, or the oxidation of methane and other hydro-carbons, we can little hope to deal with the more complicated oxidation processes, like those associated with the plant cell.

In so simple a reaction as the oxidation of carbon, the mechanism and even the nature of the primary products of attack are only partially known. In the region 400–500 deg. Cent. something has been learnt as the result of the researches of Hinshelwood and his associates.[2] Apparently the oxygen directly attacks the crystalline carbon surface, and forms relatively stable surface complexes of carbon and oxygen; some of these complexes can resist a temperature of 1100 deg. Cent. before being broken up. Besides these complexes, which have little to do with the mechanism of the combustion reaction, at certain favourable regions of the carbon lattice, perhaps in between the lattice planes, the oxygen forms a particular intermediate compound with the carbon to give carbon dioxide only, which then leaves the surface. Thus the first product would be carbon dioxide and not carbon monoxide. Above 500 deg. Cent. it appears that carbon burns to give both these gases, but there is as yet no precise knowledge of the process; the detailed work of Sihvonen and of Mayer is not in agreement, and further research is needed.

Carbon dioxide is a "straight molecule" [O=C=O]; the oxygen and the carbon are "in line," but the spectrum of burning carbon monoxide is characterised by a very large number of bands, the origin of which have not yet been definitely decided. Dr. Gaydon, working in our laboratory,[3] has measured these bands and found reason to interpret their grouping as due to carbon dioxide molecules undergoing an electronic transition to the ground state and that after this transition they would be left with vibrational energy owing to the molecule being no longer a straight molecule, but one in which the oxygen and carbon are "out of line" $\left[\begin{matrix} & C & \\ O & & O \end{matrix}\right]$. This probably has much to do with the "after burn" which has been observed during combustion in various circumstances. Carbon monoxide when completely dry can be burnt to CO_2, as Professor Bone showed in an exhaustive series of experiments, but the combustion is greatly facilitated by the presence of water and the OH band is then prominent in the spectrum. The exact mechanism of combustion at high temperatures is difficult to establish; we have only the emission spectra, the structure of flames, and the products as a guide; but at lower temperatures (below the region of ignition) the reactions are slowed down and it is possible to study them in greater detail.

* The twenty-seventh Thomas Hawksley Lecture, Institution of Mechanical Engineers, November 15th, 1940.—Abstract.

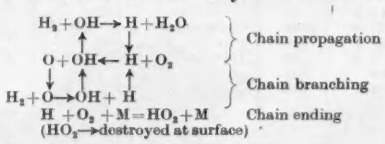
[1] The Samuel Commission (1926) concluded that if the rate of output of coal in Great Britain remained constant the known reserves would last four to five centuries. Many have expressed opinion that the resources of coals of special quality should be more carefully conserved than they are at present.

[2] Strickland Constable, 1940, *Fuel*, Vol. 19, p. 89.

[3] Department of Chemical Technology, Imperial College of Science and Technology, South Kensington. See Gaydon, "Proc.," Roy. Soc. (forthcoming issue).

The results obtained with carbon monoxide are, however, not easy to interpret and even the slow combustion of hydrogen in oxygen is quite a complex process, so complex that books[4] have been devoted to the interpretation of the experimental results. There are three stages in combustion: The slow reaction before ignition, the ignition itself, and then the reaction in the flame. But it is not even as simple as that, as we shall see.

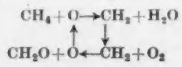
Ignition Limits.—A hydrogen-oxygen mixture run into an empty heated silica vessel will only explode when a certain low critical pressure is reached; it continues to explode above such pressure until again, beyond a certain upper critical limit, the mixture no longer ignites, although the pressure is greater, but simply reacts without igniting. It has been found that these results have an interpretation if the reaction is considered as a "chain reaction"; one such chain reaction mechanism may be illustrated thus:



When the free, but short-lived, radicals OH or H meet the molecules of hydrogen or oxygen, they propagate the reaction, giving H_2O and oxygen atoms which, unless destroyed, can give rise to OH and H, and so to new chains, and thus, by rapid development of the reaction, ignition is brought about. The lower limit below which explosion does not occur is due to destruction of the radicals at the walls of the vessel, which they hit before hitting another molecule, and so the chain is stopped and ignition prevented. The upper limit is due to a triple collision of an active radical with other molecules in the gas mixture, which likewise breaks the chain. Both by too few molecules and too many molecules, the chain of reaction is stopped. There seems to be no other way of interpreting the peculiar results of pressure than by assuming a chain reaction.

We must leave the many intricacies of this subject, but the important point to recognise is that ignition may not only be a thermal process which occurs when the heat gain due to reaction surmounts the heat loss, but it can also be due to "branching" which can give rise to extra radicals and therefore to the propagation of more chains of reaction. The reaction then "runs away with itself" and ignition occurs.

Ignition of Hydro-carbons.—Passing now to the hydro-carbons, we again come across, with methane, the limit phenomenon occasioned by pressure; there seems to be little doubt that the reaction proceeds by a chain mechanism. Furthermore, the slow reaction of methane in silica vessels can be interpreted in terms of a chain reaction. Professor Norrish[5] has adopted the following scheme to interpret his measurements on the slow oxidation of methane



The mechanism of the slow combustion of hydro-carbons is rich in interest, but we will mainly discuss their ignition. Some fifteen years ago our experiments indicated that peroxides played a prominent part in hydro-carbon oxidation, and at about the same time Callendar and Mardles, and Moureu in France came to a similar conclusion. Bone held tenaciously to the view that the oxidation of a hydro-carbon proceeded through the alcohol in successive stages of hydroxylation, and was opposed to a peroxide being considered a necessary step in the oxidation. He brought forward quite strong evidence in support of his views. For instance, Dr. Newitt showed that as the pressure was increased, larger quantities of alcohols were found in the products of combustion of methane and ethane. As time went on, the *rôle* of the peroxides became clearer.

It has been known for some time that the hydro-carbons, except for methane, can give rise to a strong glow or cool flame at quite low temperatures; Prettre's results (Table II) illustrate this. Townend and his associates at South Kensington[6] found that on increasing the temperature at a given initial pressure a region of slow reaction is first formed, then ignition occurs, then again above this temperature only cool flame would appear; still further above this, there would be slow reaction, until at a high temperature true ignition takes place again.

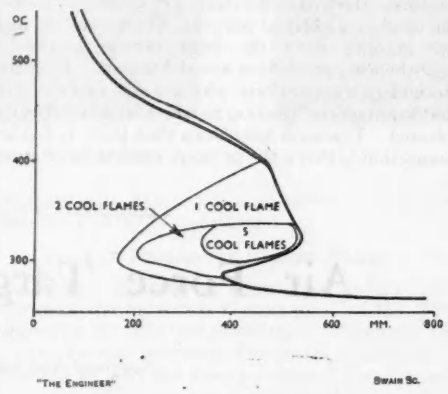
With oxygen mixtures, these ignitions occur at lower pressures, but the same features make their appearance (see engraving). At South Kensington, Newitt and his associates[7] have made careful

TABLE II.—*Ignition of Hydrocarbons* (1 *Atmos. Pressure*)

Vapour.	Luminescence, deg. Cent.	Lower ignition, deg. Cent.	Higher ignition, deg. Cent.
Methane	740	—	770
Ethane	380–410	—	660
Propane...	265–305	—	672
Pentane...	221–240	262–292	681
Hexane	220–244	255–270	672
Heptane	210–233	259–269	695
Octane	200–220	252–270	684

analyses of the products of oxidation at the various stages of the reaction, not only starting with the parent hydro-carbon, but also with intermediate products which are formed during the oxidation, such as aldehydes, and it has become abundantly clear that peroxides are playing a prominent part in the reaction both of the parent hydro-carbon and of the aldehyde.

Dr. Harris and I at South Kensington[8] have carefully investigated the decomposition of some of the organic peroxides and have learnt something about their behaviour. Diethyl peroxide, for



IGNITION OF PROPANE $1C_3H_8/1O_2$

instance, will decompose at 180 deg. Cent. quite slowly and quietly, uninfluenced by surface, provided the initial pressure is not greater than a few centimetres of mercury. But at a certain critical pressure the decomposition becomes suddenly quite violently explosive. We have proved that this sudden change over to explosion is a thermal effect and that it is much influenced by the size of the vessel in which the experiments are conducted. If diethyl peroxide is let into air, a flash occurs at a pressure a little lower than that at which the decomposition would occur of its own accord. On the other hand, if it is let into a hydro-carbon-air mixture, it may flash without even igniting the hydro-carbon.

Bearing these facts in mind, let us inquire into the process of ignition a little further. When a hydro-carbon-air mixture is let into a heated vessel, ignition does not occur at once. There is a delay—it may be a long delay of thirty minutes or more. Depending on the circumstances, we may get a delay, and then a "cool" lambent flame or several successive cool flames, or after the delay there may be a "cool" flame rapidly developing into true ignition, giving the ordinary bright flame. Combustion after the passage of a cool flame is very incomplete; combustion after true ignition is much more complete.

Experiments have shown that ignition is composite. Though sometimes it seems to be a single process, if the conditions are a little changed it is clearly a double process. There is first a delay before cool flame ignition and then quite a short delay before true ignition sets in after the cool flame. Townend and Mandlekar, and later Kane,[9] found these effects at South Kensington; Neumann has also investigated the matter in Russia. In order to explain them, Neumann[10] suggested that the process of combustion can be symbolically represented A→B→C, or A→C (B being an intermediate product). What happens depends on the relative rates of the reactions A→B and B→C; if A→B is rapid and B→C at a given temperature is slow, B will accumulate. If at a higher temperature B→C becomes faster than A→B, then A will go direct to the end product without accumulation of B. But this was only another way of saying that there was an intermediate product such as a peroxide which could accumulate. This, however, is not the complete explanation; Semenof showed that if b is the probability of a reaction chain branching so that each primary link in the chain gave rise to a new radical and so a new chain, and if a is the chance of the chain being broken and stopped, and if w is the rate of reaction, then $w=A(e^{\varphi t}-1)$; the net branching factor φ, which is $b-a$, controls the development of the reaction and if $a>b$, the reaction is stopped; but if $b>a$, it goes to infinity, *i.e.*, to ignition. There may be some slight delay before b increases sufficiently to overcome a, but such delays are short. Now in order to explain long delays, Semenof[11] ingeniously suggested that the chain reaction was debased or became "degenerate," and that some of the radicals instead of continuing the chain formed a stable intermediate body, which could either give rise to more chain centres or be oxidised to an end product and removed from further effect. On this idea smaller values of φ are obtained and the reaction is very slow and almost negligible at first and then develops more and more rapidly, and this explains the long delays which can occur. If destruction of the intermediate occurs mainly at the walls, then it can be shown from Semenof's theory that the slow reaction will suddenly cease altogether below a certain tube diameter. Norrish has recently shown this to be the case for a number of hydro-carbons.

Before putting these ideas together to elucidate the ignition of hydro-carbons, a further set of experiments must be mentioned.

White (1927)[12] observed that for ether-air mixtures there were two quite distinct composition ranges for inflammation, one for normal ignition and the other for cool flames and that above a critical pressure the cool flames could give rise to normal ignition by initiating a second flame in the cool flame products. Townend[13] has shown that this two-stage process of ignition is just the same whether the cool flames are induced in the gas mixtures spontaneously at the higher temperatures and at suitably low pressures, or whether they are induced artificially by heating a portion of the gas with a wire or other igniting source at room temperature and at rather higher initial pressures. He has extended the work to show that hydro-carbons, which give rise to cool flames, also give at the higher pressures and lower temperatures these two-stage flames; first the cool flame appears, and then the normal flame follows in the cool flame products.

Now let us consider ignition of a hydro-carbon mixture from the two points of view given in the next two paragraphs.

(1) The mixture is let into a heated vessel; it picks up heat from the walls and amongst the more energetic molecules oxidation commences, which means that some aldehydes will be produced; these absorb oxygen and probably form a "moloxide," such as the work of Baxt and Newitt seems to indicate. This "moloxide" is unstable and undergoes decomposition, and in so doing gives our chemi-luminiscent light; or it may produce a second fairly stable intermediate peroxide. The peroxide decomposes when it reaches a critical concentration, as has been shown by Harris, and releases energy. It need not necessarily lead to ignition, but it can do so if the energy cannot get away; then normal ignition occurs.

(2) A part of a cold mixture is heated by a source of ignition, and since the mixture is at a high enough pressure, inflammation is started. It is not the whole gas which is heated, only a portion of it. Activated products spread out from such centres into cold unburnt gas; if the pressure is sufficiently high there are enough centres to propagate reaction chains in the unburnt gas, and products are formed which decompose and give a blue chemi-luminiscent flame, or if heat cannot be dispersed the blue flame will be followed by normal bright ignition, in the way already described.

Although the whole complex process of ignition of a hydro-carbon is not yet quite cleared up,

[4] Hinshelwood and Williamson, 1934, "The Reaction between Hydrogen and Oxygen," Oxford University Press.

[5] Norrish and Foord, 1936, "Proc.," Roy. Soc., Vol. 157, p. 503.

[6] Townend and Mandlekar, 1933, "Proc.," Roy. Soc., Vol. 141, p. 484.

[7] Newitt and Thornes, 1937, *Jl.*, Chemical Soc., p. 1656; and Newitt and Baxt, 1939, *ibid.*, p. 1711.

[8] Harris and Egerton, 1938, "Proc.," Roy. Soc., Vol. 168, p. 1.

[9] Kane, 1939, "Proc.," Roy. Soc., Vol. 171, p. 251.

[10] Neumann and Aivazoff, 1935, *Nature*, Vol. 135, p. 655.

[11] "Chemical Kinetics and Chain Reactions," Oxford University Press, 1935.

[12] *Jl.*, Chemical Soc., 1927, p. 498.

[13] Hsieh and Townend, 1939, *Jl.*, Chemical Soc., p. 332.

considerable advances have been made in the last few years and the whole story is beginning to piece itself together. The propagation of flame depends on the rate of reaction of the ignitible mixture where it meets the flame boundary. The understanding of ignition is thus essential to an accurate understanding of the processes which control flame travel.

"Knock"

The picture of the world that we have in our minds is not reality; it is only an image coloured by the historian, or cast into relief by the journalist. Reality cheats us as does the conjurer—we think of our destiny as shaped by the advent of a Lenin or a Hitler, whereas they are only specific influences in the interwoven fabric of destiny. The advent of the steam engine, or of the internal combustion engine, or of antiseptics, have as much justification to be considered potent influences as the conquests of a Napoleon. Quite little things often have great effects:

> We are the Little Folk—we!
> Too little to love or to hate.
> Leave us alone and you'll see
> How we can drag down the Great!

In the Rede Lecture entitled "The Causal and the Casual in History," John Buchan traced in a delightful way the influence of the incident on the course of history—how, for instance, it might have been all different if, on November 9th, 1799, Napoleon had not unwittingly scratched his face and made it bleed, whereon his brother, Lucien, by his eloquence, won for him the sympathy of the crowd. One might trace in many such ways, the effects that a little chance natural phenomenon may have on human history.

One of these influences or incidents is the phenomenon of "knock" in combustion. When a flame passes through an explosive mixture, towards the end of the flame travel, it may suddenly change its character. Suddenly in the small portion of the gas remaining to be burnt, there will be a local explosion and that region of gas will burn with much greater rapidity. A wave of pressure passes back through the products of combustion. This effect is what has come to be known as knock. Knock has been the main limiting factor in the design of petrol engines. Much ingenuity has been spent in designing engines to get the maximum energy out of a fuel without encountering the troubles caused by knock. Knock has led to great activity in the oil industry, so that out of crude oil the greatest amount of fuels which show the least tendency to knock can be produced. Knock has determined policy; knock may come to determine air supremacy, which will shape the future history of the world.

The following table shows some of the processes which are used to improve the quality of fuels, to prevent their tendency to knock. The ignition products are the crude oil and the casing head gas. The crude oil is "stabilised," *i.e.*, further quantities of gas are removed; the products, stabilised crude and gas, are then treated in a variety of ways. The stabilised crude oil may first be distilled into fractions which are subsequently treated by the many improvement processes. Both the primary "saturated" gases, and the more "unsaturated" gases obtained from the cracking processes, are also subjected to treatment.

Treatment of Petroleum

Thermal cracking and reforming.
Catalytic cracking and reforming.
Polymerization:
  (*a*) Thermal,
  (*b*) Acids,
  (*c*) Supported phosphates,
  (*d*) Metallic phosphates and sulphides.
Hydrogenation cracking.
Hydrogenation polymerization.
Hydrogenation.
Dehydrogenation.
Alkylation:
  (*a*) Acids,
  (*b*) Thermal high pressure.
Isomerization.
Aromatization.
Ring closure.

In order to measure the knocking propensity of a fuel it was decided that the fuel should be tested in an engine specially built for the purpose and running under a standard set of conditions. If the knock shown by the fuel was the same as that of a secondary standard fuel which tallied with that of a 40 per cent.–60 per cent. mixture of *n*-heptane and "iso-octane" (2–2–4–trimethylpentane) then the octane number of the fuel would be deemed 60. The trouble comes when the octane rating so obtained has to accord with the behaviour of the fuel under practical conditions on the road or in the car. That is a long story of co-operative research, which I cannot relate now. The harmless organic chemical, 2–2–4–trimethylpentane, obtainable in the first place in quantities of only a few cubic centimetres, and used only as a standard for fuel testing, in a few years has become perhaps the most important of the refined products of industry. It has made possible the immense speed of modern aircraft and has influenced the development of the new aliphatic chemical industry which has arisen within, or as an offshoot of, the petroleum refining industry.

With all the expenditure on huge schemes for the production of high-octane fuels, with the intensity of research on methods of conversion of the poor constituents of crudes into useful constituents, insufficient attention perhaps has been paid to the study of their combustion, for after all it is their combustion which alone determines their behaviour and enforces their use.

Table III gives the octane numbers of various hydrocarbons:[14] the normal straight-chain paraffins, aldehydes, &c., have low octane numbers; the most symmetrical paraffins, the aromatics, and the ketones have the high octane numbers; naphthenes and olefines stand between. It is the straight-chain paraffins which most readily give that low region of ignition to which we have already referred. Townend has shown that there is a close connection between the pressure needed for ignition with short delay in this region and the highest compression pressure which the fuel mixture will withstand in an engine before knock ensues. From what has been said about ignition, it is evident that substances are formed in the products of the cool flame or in the products of the slow combustion, which decompose and lead to ignition. This is in agreement with the view, put forward in 1927, that in the last portion of a charge to burn, intermediate substances were formed which enhanced the combustion when the flame reached them and so led to knock. The processes of knock and of ignition have much the same cause. In both cases the intermediate substances are almost certainly peroxides, derived from the aldehyde in the case of ignition, but it is not yet quite clear whether the same unstable peroxides are responsible in the case of knock, or whether they are not more stable ones, like diethyl-peroxide, which have been formed by a secondary process and exist in the pocket of gas in which the knock is set up. The peroxides which so far have been found to give rise to knock when added to the fuel in the same very small concentration (10^{-5}) as those which have been sampled from engine gases, are the dialkyl or alkyl hydrogen peroxides, but there is much yet to do in this field of investigation.

Table III.—*Typical Octane Numbers*

Hydrocarbon.	Boiling point, deg. Cent.	Octane number.	Hydrocarbon.	Boiling point, deg. Cent.	Octane number.	Hydrocarbon.	Boiling point, deg. Cent.	Octane number.
Ethane	— 88	104	—	—	—	Ethylene	—102·4	81
Propane	— 42	100	—	—	—	Propylene	— 47·7	85
Butane	— 0·5	92	2-Methylpropane	—12·2	99	—	—	—
n-Pentane... ...	35·9	61	2-Methylbutane	27·8	89	Cyclopentane ...	49·2	83
n-Hexane	68·7	25	2-2-Dimethylbutane ...	49·7	96	Benzene	80·1	108
n-Heptane ...	98·4	0	2-2-Dimethylpentane ...	79·3	93	Toluene	110·7	104
n-Octane	125·7	—17	2-2-3-Trimethylpentane .	110	102	—	—	—
—	—	—	2-2-4-Trimethylpentane .	99·1	100	—	—	—

Air Force Targets in Germany

No. XII

(*Continued from page 313, November 15th*)

Sterkrade-Holten Oil Works

EQUALLY important synthetic oil plants to those operating on the Bergius hydrogenation principle, to which we have referred in our last two articles, are those which utilise the Fischer-Tropsch synthetic process, in which liquid hydrocarbons are produced from a mixture of carbon-monoxide and hydrogen. This process is independent of the type of fuel from which the synthesis gases are produced, and is in use in plants which have been erected in all parts of Germany. Among these, many have been bombed on different occasions by aircraft of the Bomber Command of the Royal Air Force, as part of its programme of long-term interference with Germany's war effort. Such plants include those at Castrop-Rauxel, the Dortmund works of the Hoesch Benzin A.G., the Kamen factory of the Chemischewerke Essener Steinkohle, the Rheinpreussen works at Homburg, the Krupp Treibstoffwerke at Wanne-Eickel, and the Sterkrade-Holten oil works of the Ruhrbenzin A.G. It is calculated that before the beginning of the war, no less than 1,000,000 tons of Fischer-Tropsch products were being produced yearly by the plants operating on this process, since which it is known other important installations have been set to work.

General View of Sterkrade-Holten Oil Works

Process Developments

Work on the synthesis of hydrocarbons from hydrogen and carbon-monoxide dates back to 1902, when Sabatier and Senderens in France showed that methane could be produced catalytically from a mixture of hydrogen and carbon-monoxide. The catalysts used were of the iron and platinum groups, at a temperature of round about 200 deg. Cent. At a later date, about 1913, it was discovered by the Badische Analin- und Soda-Fabrik that mixtures of hydrocarbons and oxygenated compounds could be produced from a mixture of hydrogen and carbon-monoxide at higher working pressures. Ten years later Franz Fischer found that iron turnings could be used as

[14] Smittenborg and others, 1940, *Jl.*, Inst. Petroleum, p. 294.

a catalyst, and a mixture termed "Synthol" was produced. In 1925 the Badische Analin- und Soda-Fabrik developed the catalysts and by using mixed catalysts developed the production of methanol from synthesis gases.

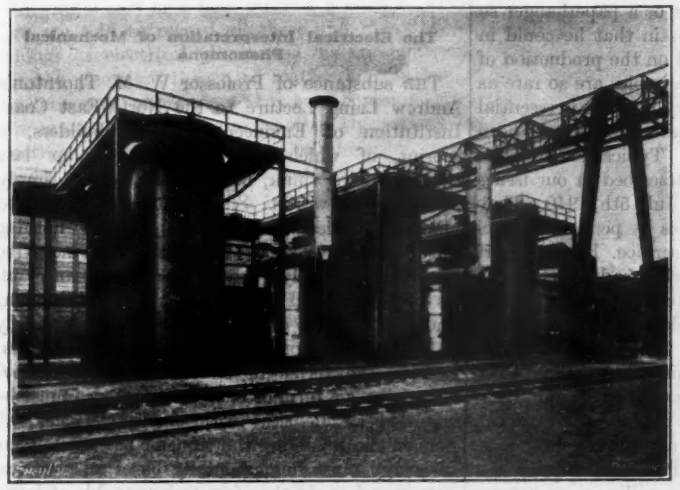
In the same year came the epoch-making work of Fischer and Tropsch, which proved that a reaction, yielding hydrocarbons, could be carried out with an almost negligible formation of oxygenated compounds, and, further, that by using a suitable catalyst, the operation could be conveniently performed at a low working pressure. This pioneer work was continued until 1924, when the Ruhrchemie A.G. decided to take over the commercial development of the Fischer synthetic process. In a comparatively short time the laboratory work was followed by a small-scale plant, and later a semi-commercial plant, which work led eventually to the construction of the many large-scale oil plants to which reference has been made above. In addition to German plants, others have been built in different parts of Europe and the Far East.

The synthetic process is less dependent on the character of the fuel supply than is the hydrogenation plant, as in this process raw materials are not partially broken down solid fuels, but are hydrogen and carbon-monoxide, which can be generated by many different means. The basic reactions of the Fischer-Tropsch synthesis process may be stated as follows :—

$$n\,CO + 2n\,H_2 \xrightarrow{\text{catalyst}} C_nH_{2n} + n\,H_2O$$

$$n\,CO + (2n+1)\,H_2 \xrightarrow{\text{catalyst}} C_nH_{2n+2} + n\,H_2O$$

In the actual process about 1 lb. of hydrocarbons requires 110 to 125 cubic feet of synthesis gas, which can contain about 13 per cent. of inert gas. The fuels which may be employed in order to produce the necessary large volumes of hydrogen and carbon-monoxide forming the synthesis gas include caking and non-caking bituminous coals, brown coal in briquettes or powder, and coke in various forms. Various types of gas generators have been developed for this purpose, and different designs of plant are to be found at the various works. They include the ordinary type of water-gas generator, using high temperature or low temperature coke, which may be accompanied by the cracking of the coke oven gas in the generator in order to produce a 2 to 1 hydrogen to carbon-monoxide ratio. The same kind of plant is also used with non-caking bituminous coals. Other plants include that of Bubiag-Didier, designed to gasify non-caking coals direct and Wintershall-Schmalfeldt for brown coal. For brown coal a special generator to produce synthesis gas has also been designed by Koppers, and the Winkler generating plant employs brown-coal coke, while the Lurgi process has been developed to use non-caking bituminous coal, brown coal, or coke, in a pressure process making use of oxygen.

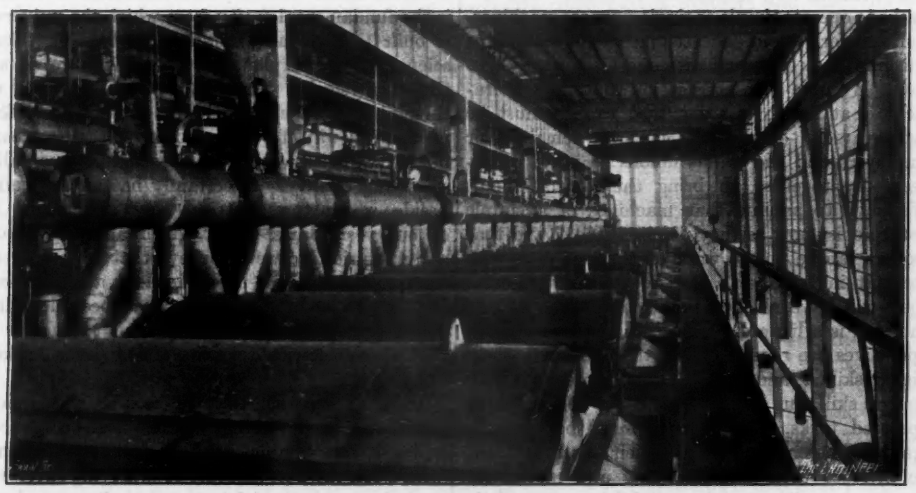


PLANT FOR REMOVAL OF ORGANIC SULPHUR COMPOUNDS

ACTIVATED CARBON PLANT

THE STERKRADE-HOLTEN PLANT

In the accompanying engravings we show some views of the Sterkrade-Holten plant of the Ruhrchemie A.G. The first illustration is a general view of the factory, showing the works buildings, the gasholders, and the storage tanks. The first step in the working process is the production of the synthesis gas, with a hydrogen to carbon-monoxide ratio of 2 to 1. Besides the generators using coke, a catalyst process is employed, in which carbon is rejected as carbon-dioxide in order to adjust the ratio of hydrogen to carbon-monoxide. Having made the gas, it is necessary to render it practically free from sulphur compounds, as sulphur causes a rapid deterioration of the catalyst. In the German factories the hydrogen sulphide is generally removed by the ordinary iron oxide process, but special plant has been developed in order to remove the organic sulphur compounds from the gases. In one of the accompanying illustrations we show the plant installed at Sterkrade for that purpose. It operates on the Roelen and Feisst principle, which involves passing the synthesis gas over a catalyst at temperatures from 350 deg. to 570 deg. Fah. The organic sulphur compounds are broken down and fixed in the catalyst. A further advantage of this particular process is that the synthesis gas leaves the purifier, at substantially the temperature at which the subsequent synthetic process is carried out, so that no great amount of heating or cooling is needed. The catalysts employed have included an alkaline form of iron oxide, which is specially prepared.



BATTERY OF SYNTHESIS UNITS

The synthetic process has been the subject of careful research work in order to maintain high yields and to keep the catalyst active over long periods. The life of four to six months has now been reached in production and using a combination of atmospheric and medium pressure at about 10 atmospheres, an overall carbon monoxide conversion of over 90 per cent. is now possible. A laboratory is set apart in the works for the testing of new catalysts and the control of industrially prepared catalysts. In the synthetic process a considerable quantity of heat is evolved, which amounts to about 20 per cent. of the heat of combustion of the synthesis gas or approximately 7500 B.Th.U. per lb. of products. Water cooling is employed, and steam is produced at pressures as high as 225 lb. per square inch. As previously stated, the synthetic process is carried out both at atmospheric and medium pressures. An engraving herewith illustrates a battery of synthesis units of the atmospheric pressure type. The medium pressure units are not illustrated. In the illustration the horizontal units will be seen with the steam drums arranged over them at the ends. The catalyst is arranged on the outside of a horizontal tube provided with fins, the gas passing along the outside of the tubes and the cooling water inside the tubes. In the pressure synthesis units the catalyst is placed within specially designed vertical tubes, with the water circulating around them. In both cases effective cooling is obtained and it is possible to regulate the temperature of the reaction by controlling the steam pressure.

On leaving the catalyst chambers or units the products are cooled, direct cooling being employed in the atmospheric process and indirect cooling in the medium pressure process. The hydrocarbons are recovered from the gas, either by oil absorption or activated carbon. The absence in the products of the process, of sulphur and gum-forming products, renders the activated carbon method particularly applicable, and the plant at Sterkrade, which operates on the Fischer-Ruhrchemie principle, is illustrated herewith.

In the pressure operation oil absorption is used, the lean oil employed for this purpose being a fraction of the synthetic product. The remaining or tail gas contains some inert constituents, but it can be employed for road transport and for heating purposes on the plant. The primary products require further treatment. They are straight-chain hydrocarbons, and the petrol fraction produced has therefore a low octane number and the diesel oil a high cetane number. The paraffin wax fraction can be converted into waxes of various melting points, and a large-scale product is a wax which has a melting point of 195 deg. Fah. Part of the Fischer product can be utilised for the production of synthetic lubricating oil. Two methods are available. In one suitable paraffin hydrocarbons are chlorinated and are combined with aromatic hydrocarbons ; and in the other the heavy olefins are polymerised by using aluminium chloride. For some years past lubricating oils produced by the polymerisation process have been in commercial use in Germany.

The Engineer

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TRAINING LABOUR FOR WAR PRODUCTION

WHEN unemployment was the gravest industrial problem of the day, the practice of giving monthly returns of the number of persons unemployed grew up. Attention was focused on the people out of work instead of on those in it. No one seemed to be so much concerned about the number of persons gainfully employed as about those in receipt of out-of-work pay. It would always have been more instructive to publish the figures showing the rise and fall of employment, but the country was thinking less about that than it was about those who were out of work and the causes of their enforced idleness. Illogical and even misleading as it might be, that was a natural and human course to pursue. But it is very doubtful that it is now wise to continue it. The number of unemployed, as Mr. Bevin has pointed out on at least one occasion, calls for several qualifications before its true significance can be appreciated. On the other hand, there is far less ambiguity about the number for those in employment. From it the public could tell at once the rate of increase or decrease in the quantity of labour that is engaged upon the essential services—munitions and export—of the land. This figure could at one time be obtained from the *Labour Gazette*, but since the war started the numbers of those employed in industry are no longer made public.

Detailed figures, such as we were accustomed to, could be very instructive, too instructive, perhaps, to be suitable for publication in the present circumstances. We do not know, and are not likely to be told, what numbers of men and women are engaged on the direct production of munitions, on shipbuilding, aeroplane manufacture, or upon each of the many industries that are wholly or partly doing war work. All we do know is that several hundreds of thousands of wage earners have been drawn out of industry for the military services; that some industries—notably coal mining—are suffering by the decline of overseas markets, whilst others for lack of raw material or demand have had to reduce the number of persons employed. It would be an ideal condition could we at once take all those brought up in an industry that is, for the moment, depressed and put them immediately to the production of war supplies. That is, in general terms, impossible. Here and there one might find a miner or a paperhanger so skilful with his hands and brain that he could in next to no time be employed on the production of shells or tanks. But such examples are so rare as to be negligible. Preliminary training is essential and, as everyone knows, training centres have been set up all over the country. Typical examples of them and their work were described in our issues of April 26th, May 24th, and July 5th, 1940. They did, as we convinced ourselves by personal inspection, and are doing, excellent service. For their part many of the leading firms which already had training schemes in operation have extended them or intensified the courses. Nevertheless, this great effort has not been sufficient and it is understood that a million more operatives may be required next year. That is very good news, for it shows that the increase of capacity is rapidly taking form. For many months we could not employ more than we did. There was neither the accommodation nor the equipment for them. If a million more persons are to be engaged on war material production in 1941 than were so engaged in 1940, it is a fair deduction that our means of production are increasing at a very satisfactory rate. The problem now is to find this large army of workers rapidly. In the engineering industries that gives rise to two considerations. First and foremost, it is certain that the need cannot be satisfied from available skilled man-power alone. It is certain that more men will be called next year to the colours and that the number remaining will not be sufficient to meet the need. We must do, as we did in the Four Years' War, employ a great many more women. The obstacles and objections to this form of dilution must be broken down. It is well known that women can be trained in a few weeks to operate simple or single-purpose machines, and that for certain delicate operations, like gauge finishing, they are equal with and often superior to men. We note with satisfaction that the Government is at length insisting that women must be more largely employed; it now remains for employers and the trade unions to work wholeheartedly together to bring this object about. We have to assume that machines of a simple nature exist now as they did in 1916–17 and that women can be put to work on them at once with the certainty that in a few weeks—six at most—they will have reached proficiency. The case of the men is a little different. Two classes of male operatives are required. On the one hand, those highly skilled, and on the other, those with little general skill, but sufficient ability to perform a few specified tasks. The former must be carefully trained, not only to develop their handicraft, but to increase their understanding and mechanical intelligence. The training establishments and the apprentice benches in works have so far concerned themselves principally with this skilled class. They are turning out by intensive training qualified mechanics; men who are able to handle the file and scraper, and understand machine tool operations. But many thousands of much less skilled men could be employed on work too heavy for women, and it is to be hoped that several months of training will not be thrown away on teaching them crafts which they will never be expected to exercise.

The employment of partially trained men and women really turns upon the design of the machines and equipment they will be called upon to use. Given sufficiently simple tools, there is no reason at all why anyone of average intelligence and reasonable muscular strength should not be able to operate them properly after a few hours of instruction. It is doubtful, indeed, if any special training is called for in this class of worker. Men and women could be started straight away upon the simplest types of lathe operations and advanced as they became more proficient. That course was pursued in the Four Years' War and proved quite satisfactory. Those that require training are the selected few who will be required to set and supervise the work of the less skilled. It would be a mistake to spend more time and money on training others than is necessary. Our object now is not to turn out a large number of competent male and female mechanics, but to provide rapidly an army of workers capable of performing a few very simple operations.

The Electrical Interpretation of Mechanical Phenomena

THE substance of Professor W. M. Thornton's Andrew Laing Lecture to the North-East Coast Institution of Engineers and Shipbuilders, a reprint of which we completed in our last issue, can, we think, be expressed quite simply and in a few words. Since matter, according to modern physical doctrine, consists of nothing but planetary systems of positive and negative electricity, namely, protons and electrons, all its properties and every aspect of its behaviour under any kind of conditions must ultimately be electrical phenomena and be capable of explanation in the terms of electrical science. Since electricity is a form of energy matter also must be regarded as identical with energy. Hence, all phenomena involving the transfer or transmission of energy must fundamentally be of an electrical nature and ought therefore to be capable of being brought within the ambit of one general law. No one will quarrel with the right of electrical engineers to explain the transmission of electricity in terms which are purely electrical, although in passing it may be remarked that not so many years ago the efforts of many physicists were bent in the direction of endeavouring to explain electrical phenomena on a mechanical basis. When, however, electrical engineers claim to be able to explain all mechanical phenomena in terms of electricity, our first impulse is naturally to ask whether they are now so sure that they understand the nature of electricity that they can with certainty transcribe what have long been referred to as mechanical phenomena on to an electrical basis. Are they so certain that electricity is the fundamental entity from which the universe is built that we need not look beyond electrical science for an explanation of the nature of all things physical? There is a mechanical way of thought and an electrical way of thought. The mechanical way, to most people at least, appears not only to be easier, but to possess a fundamentally satisfying quality. It certainly has an antiquity beside which the electrical way of thought is of but yesterday's birth. After all these years and centuries are we to believe that in seeking to interpret mechanical phenomena on a mechanical basis physicists and engineers have been deluding themselves and that the only road to success is that which electrical science claims to have marked out?

It is conceivable that in seeking mechanical explanations of things mechanical—a search which it must be agreed has, on the whole, met with a considerable measure of satisfying success—engineers and physicists may, as it were, have accustomed themselves to speaking in a language which they do not fully understand, to expressing their ideas in a kind of shorthand, the key to which is not in their possession, but is held by the electricians. A number of facts seem to support such a suspicion. Corrosion, at one time considered to be a purely "chemical" phenomenon, is now known to be determined in all its various aspects by the existence of certain electrical conditions which, it has been discovered, accompany it. Many other phenomena which at one time were considered to be purely "chemical" are now universally recognised as being fundamentally electrical in their nature. Stepping outside the field of chemistry we find biologists turning more and more to electrical science for explanations of muscular movement and other cognate subjects. In the mechanical world lubrication is no longer

considered to be a purely mechanical phenomenon. Chemistry has been invoked to explain some of the results observed under conditions of boundary lubrication, while to account for those observed when a metallic oxide—such as zinc oxide—is present in the lubricant seems to be impossible unless electrical phenomena are admitted as playing a decisive part. Undoubtedly, these and many other phenomena, not at first sight electrical, do admit of an electrical explanation and, indeed in most cases, are apparently inexplicable on any other basis. When, however, we are asked to regard combustion, the action of steam pressure on pistons, the transmission of energy through shafts and belts, and even the action of a horse drawing a cart or a man pushing a barrow, when we are told to regard all these and many other things as electrical phenomena, as consequences of the electrical theory of matter and as being in common subservient to one common law, we must pause to inquire whether the statement is true and to what degree the admission of its truth would advance our understanding of natural phenomena and the ability to control them which we desire to exert. Science, as we said on a recent occasion, is really designed as a means of economising human thought. If a short-hand language serves to explain any natural phenomenon it is not economical and, by inference, not scientific to translate it into a longer hand which has yet to establish its claim to be the final mode of expression.

Supporters of the theory of relativity and of the quantum theory would doubtlessly maintain that in seeking to interpret all phenomena, electrical and mechanical, on an electrical basis Professor Thornton does not go far enough. The ultimate verities of Nature, they hold, are to be found not in mechanical science, nor in electrical science, but shrouded in a cloud of pure mathematics. Reading the printed copy of his lecture we cannot avoid the impression that the structure which Professor Thornton has raised on the authority of Poynting's law is based on a divided allegiance to two distinct schools of thought—the old, or classical, and the new, or relativistic, doctrines. He accepts the view that mass, electricity, and energy are convertible terms, a view which definitely belongs to the Einstein era. Yet he subsequently speaks of the ether and of the existence of strains in it in a manner which seems to be fully in consonance with the usage of pre-Einstein days. In a synopsis accompanying the printed copy of the lecture, it is stated that the nature of gravitational potential energy is unknown, a statement which may be traced to the influence of the theory of relativity. Nevertheless, at the end of the third paragraph of the lecture, we read that "a weight when raised acquires potential energy from the added elastic strain of the ether of space that carries gravitational forces." This statement would seem to be not only an explanation of the nature of gravitational potential energy, but to be an explanation thereof which is in harmony with the pre-Einstein school of philosophy. It is, of course, quite possible that if he were given sufficient opportunity Professor Thornton would be able to remove our doubts concerning these apparent inconsistencies and to show that his views on the electrical nature of matter and of the transmission of energy in any form are not derived from two conflicting doctrines. As the lecture stands at present, however, it does not appeal to us as being a wholly convincing demonstration of the electrical nature of all mechanical phenomena. Electricity may lie behind all mechanics. We do not deny it. But behind electricity, if we read aright the trend of modern physical thought, may lie other agencies which, when they are fully understood, will reveal electricity as being no more fundamental than mechanics, and a purely electrical way of thought as being no more rational than one which is purely mechanical.

War and the Railwayman

If in the new-coming world Englishmen are robbed of some of their liberties, there is at least one privilege for which they will fight, tooth and nail, to the last ditch. It is their traditional right to grumble. We all grumble about something, but the biggest grumbler of all is the railway user. He grumbles if his train is a few minutes late, if he cannot get a seat in it, if his soup is cold, if passengers stand in the corridors, if there is too much sun on one side of the carriage and too little on the other, if the luggage racks are full, or if someone else has bespoken his favourite corner. If he is a trader, he grumbles about delays in transmission, spoilt goods, lost goods, the inefficiency of depôts and sorting yards, the size of wagons, the absence of automatic brakes, and anything else under the sun that may cross him. The foreign observer who was not familiar with this English trait might, not unjustly, decide that the English railway system, passenger or freight, was the worst in the world. But if he, then, tested it for himself, he would swiftly find that there was, in fact, little to complain of, and he would come to the conclusion that Englishmen were of so proud a nature that if anything reached only an eighty or ninety percentage of efficiency they would concentrate all their attention on the missing ten or twenty per cent. and never throw a good word to the remaining eighty or ninety. In fact, that so far as the British railway system is concerned, they, reversing Prior, are never to "her virtues very kind," and never to "her faults a little blind"; but "contrariwise."

It might be expected that in the midst of a colossal war, with a new-fangled engine of destruction dropping from the sky, this privilege would be self-abrogated, that no one would ever complain if his train were overcrowded and nine hours late, or if his morning paper or breakfast fish were not ready for him at the table. But a confirmed habit is not easily knocked out of us, and however sensible and patient we may endeavour to be, the little peevishness which follows a noisy night or a tedious journey brings out the old Adam, and "we can't understand" why things are not done differently. Perhaps—note how the tendency to find fault persists—the railways themselves are a little to blame in this matter. Everyone knows that in the days before the war not with hooks of steel could he extract from the station staff the least glimmering of a reason why his train was late; yet one would have thought that in the present circumstances even the hardest-hearted censor would permit the posting-up, if not the broadcast publication, of a few facts about the conditions of stations and services more precise, more satisfying, than those which are now sometimes to be seen. If there were no other reasons the suppression of quite unwarranted rumours and murmurs would make the issue of clear statements well worth the very small risk that the enemy would be able to profit by them. A little, a very little, was done recently by the publication of a statement, prepared, no doubt, by the railways. It told us what we all know and appreciate, that "every effort is being made to maintain normal services and to restore speedily any services which may be suspended temporarily," informed us that "all the trains the tracks will carry are being run," that "bombs on railway lines damage—as we had suspected—more than sleepers," that bridges and tunnels are cracked, *débris* is thrown all about the lines, that signalling installations, power cables, telephones, lighting, and drainage may all be affected, and, finally, that when repairs are completed, obstructions removed, and signalling put right, "it is sometimes necessary to enforce a safety speed check of five, ten, or fifteen miles an hour on all trains which pass over places which have been damaged, with the result that there is an extension of time for the journey." All this will somewhat allay general grumbling, but we have not the slightest reason to suppose that every passenger or trader will forego his prerogative and his private grouse, whilst laying to his own wounds the balm that if the disorganisation of British railways is bad, that of German railways—what about the Hamm marshalling yards?—must be terrific.

Whilst we would not for a moment rob ourselves or our readers of this right to complain, may we suggest that our thoughts should go out continually to the railwaymen who are carrying on bravely in the midst of appalling dangers? They know that the railways and all that belongs to them are preferred targets of German aeroplanes. They know that almost at any moment of the night or day they may hear the ominous and sinister whine of the falling bomb, and yet they stick valiantly to their posts, giving us a service of passenger and freight trains which if it has suffered and fallen away a little from its high estate, is yet a thousand miles from being contemptible. Think of the signalmen in their great boxes near the greater stations, or keeping watches in boxes whose loneliness is their principal protection, doing a duty which calls for coolness and clear thinking night after night with the bombers overhead; or of the engine and trainmen steadily taking their trains through affected areas; or of the station staffs, the shunters in the goods yards, the men in the round houses, the permanent-way men, and the repair and maintenance gangs on the roads and bridges. Think of all these men, day after day, night after night, working in exposed positions to maintain for us a reasonable service. Think also of all those who immediately after—aye, and even during—an attack set about the task, often in darkness, of clearing up the mess so that communications may be reopened at the earliest moment, and then if there is a grumble left in you, count yourself past praying for.

Night Bombing

The martyrdom of Coventry reminds us all too painfully that the oft-promised answer to night bombing has not been found. For more than three months England, Scotland, and Wales have been bombed night after night, and we have to show in reply for the damage done no more than a handful of enemy machines brought down. It may be a fact—we sincerely hope it is—that many German machines are seriously damaged. It may also be that of the many that start out from France, Flanders, Belgium, and Denmark, some are turned back by our coastal batteries. Nevertheless, scores of planes find their way in and drop their bombs upon our cities and towns. They are, indeed, generally forced by our guns to fly at a great height. Thus we succeed in defending, to a certain extent, military and industrial objectives, but we fail to protect against a reckless enemy our historical monuments, public buildings, and the homes of our humble people or of our rich. The grim and terrible fact is that after many months of research and investigation and after the consideration, as Dr. Pye has told us, of thousands of proposals, we have got no whit forward in the discovery of an effective reply—unless the hopes to which Air-Marshal Sir Philip Joubert referred a few days ago are realised. It is true that we have multiplied our guns, that we have given them new projectiles, that we have developed the sound predictor. It is equally true that if these measures have reduced the power of the enemy to inflict damage upon us, they have not prevented him from causing much injury and heavy loss of life.

Thus far and no farther have our committees of F.R.S.s carried us! Is it not high time to engage a new pilot? Why not let practical engineers try their hands at the problem? Heaven knows if they can find an answer, but at least it would be merely common sense, when pure science has failed, to see what applied science can do. It is as likely as not that the solution—if there be one—does not lie in the realm of science at all, but in some quite common place sphere where engineers are more at home than scientists of high altitude. We would therefore suggest to the Minister of Home Security or whoever else may have the authority to do so, that he should appoint at once a committee of practical engineers for the sole purpose of examining this problem. It calls for new blood, new brains, new energy. The scientific committee may have overlooked something; let us try men with fresh ideas, young men who are prepared to dare, men who will not think so much that they see nothing but the difficulties, but will try and try new things and new ways until at last they, perchance, may hammer out something that is worth while. It is small satisfaction to excuse ourselves on the ground that Germany has failed as completely as we have to find an answer to the night bomber. She may find it whilst we are talking, and the first discoverer may forge a weapon that will turn the scales of war.

Obituary

SIR CHARLES MORGAN

EVERYONE who knew Sir Charles Morgan, and particularly railwaymen, heard of his death on November 9th with real sorrow. He was a very old man, born in 1855 and had carried into this generation much of the reticence, charm, and modesty that belonged to an earlier one. Almost to the last he retained his devotion to the railway he served for so long, and used, despite his years, to take his turn with other directors in frequent periodical visits to stationmasters along certain sections of the line.

He was born in Worcester, educated partly in England and partly in Australia, and apprenticed in 1870 to a civil engineer in Westminster. His position brought him into touch with much railway work, and he had the temerity to set up in private practice as a consultant as soon as he came of age. Those, indeed, were the days of the young and daring! Possibly he was too young to command confidence, for a couple of years later he rejoined Edward Wilson—by this time become a company—with whom he had been a pupil, and eventually became chief engineering assistant. So he continued till 1883, when the real work of his life began. He was for some thirteen years engaged by the Great Eastern Railway as Chief Engineer, under John Wilson, and then, in 1896, was appointed Chief Engineer of the old L.B. and S.C. Railway, on the resignation of F. D. Banister, holding that position until 1917, when he retired at the age of sixty-two, and was appointed a director of the company. During that time he carried out the reconstruction of the "Brighton" side of Victoria Station, completed in 1908, and the fine station at Bognor which replaced one destroyed by fire. It has been said of Victoria Station that it is a lasting memorial to him. It was during his period as Chief Engineer that the first steps in the electrification of the line took place—Peckham to Battersea Park, 1905. When grouping took place in 1923 he remained a director of the "Southern," and, as we have indicated, continued to take his duties seriously. In the Great War he undertook special work for the War Office in France and Italy, and for it was made a C.B.E. in 1918 and in 1923 received the honour of knighthood. In the same year he was elected President of the Institution of Civil Engineers, and delivered an address that was full of history about London railways.

EXPLOSION HAZARDS IN STORAGE BATTERY ROOMS

THE results of a study of explosion hazards in storage battery rooms are given in a report just issued by the Bureau of Mines, U.S. Department of the Interior. The study grew out of a co-operative investigation between the Bureau of Mines, the Boston Edison Company, and the Boston Consolidated Gas Company, which has been in force for a number of years, and has been carried out primarily for the purpose of determining the explosion hazards in manholes, conduits, and other unventilated spaces underground. Surveys were made in connection with this investigation to determine the hazards due to hydrogen in the many large stand-by type storage battery rooms of one of the co-operative companies, and to eliminate such hazards when found to exist. This report gives the average and maximum concentrations of hydrogen present in twenty-three battery rooms when the batteries were being charged, and when the batteries were on float.

The battery rooms were all of comparative large size, the volume of free air space in the rooms ranging from 13,445 to 86,678 cubic feet, and the number of cells in each installation varying from 82 to 344. Two or more surveys were made in each battery room during the investigation, covering a period of about four years. Approximately 5000 samples of battery room atmospheres were taken and analysed during the investigation. The investigation showed that the concentration of hydrogen in battery rooms was low, and no hazards were involved when the batteries were idle, "on float." Under this condition, the concentrations of hydrogen varied from zero to a maximum of 0·29 per cent. The only cases where hazardous concentrations of hydrogen were present were during the periods when the batteries were being charged and more especially towards the end of the charging period. The highest average concentration of hydrogen in any battery room tested was 5·35 per cent., and was in the explosive range of hydrogen-air mixtures.

The Burma Road and Industrial Development in China

By DR. C. A. MIDDLETON SMITH, M.Sc., M.I. Mech. E., LL.D.

NO triumph of the civil engineer has attracted such world-wide attention as the new road that connects the Burma and China frontier with the large inland provinces of Yunnan and Szechwan in Western China. The interest of millions of newspaper readers has been aroused because of the effect of the road upon the China-Japan War and with our own struggle for survival. "To-day the fortunes of Western civilisation have become inseparable from the eternal Chinese." Those words were written recently by a renowned English journalist; it is well to remember them.

Newspapers have recently explained that the Burma Road is an astounding affair, running over high mountains, down precipitous cuttings, crossing famous gorges over dizzy bridges, and that it was built in an incredibly short time by hand labour of a patient and industrious people, with no other mechanism than a stone boulder hauled by a bullock!

They have not mentioned that there were also Chinese engineers at work on the road, engineers who had had a sound technical training in well-equipped universities. They used modern materials,

THE BURMA ROAD

such as steel and concrete, for the many bridges, culverts, &c. There was no more mechanism than was in use centuries ago, when the Chinese built the Great Wall and the Grand Canal. Yet it was their knowledge of applied science, as well as the efficient manual labour of the workers, that made it possible for the Chinese to build the road over this difficult country.

Some time ago the writer described in this journal,* in detail, the engineering problems solved by the Chinese who built the road. It is now proposed to discuss "the imponderable forces" that are at work in Asia and that are rapidly changing the industrial and social systems of a large number of people in that continent. Since the spread of a knowledge of applied science has been the chief cause of these changes it may be of interest to engineers to consider them and their probable developments.

The building of the Burma Road has demonstrated what can be done by an almost unlimited supply of Chinese man power. In Malaya, Hong Kong, in China, and in other parts of the world, Chinese and British have worked together to their mutual advantage. The Chinese have supplied the man power needed for engineering and industrial schemes and the British the technical knowledge and administrative experience. It is not improbable that the present conflict will result in closer co-operation between the two nations.

Although it is my conviction that British engineers will, when peace returns, take an active part in the inevitable transformation of large areas in Asia, yet an increasing number of native engineers will be employed. The greater the number of these native engineers at work in their own countries, the more rapid will be the development of natural resources and the greater the demand for imported machinery. Foreign advice for large engineering schemes will be needed. There are now a considerable number of Chinese and Indian engineers who have a sound knowledge of applied science. My experience with Chinese engineers makes me believe that they have the patience, industry, and ability that is a sure foundation for successful work.

Moreover, the Chinese artisan is a great aid to any engineer. No more industrious and good tempered workman can be found. More than one engineer-captain, in charge of a large number of Chinese artisans in the important R.N. Dockyard in Hong Kong has expressed to me his great appreciation, and indeed admiration, for the Chinese, who so quickly learned how to use new types of machinery. Many thousands of them are in the big private dockyards in the colony, where they are building and repairing ocean-going ships of big tonnage. Many other Chinese artisans are at work in Malaya, Siam, and other parts of the Far East.

MINING AND MECHANISATION

The Japanese invasion of China has stimulated mechanisation and mining developments to an extent that seemed impossible three years ago. The Chinese intellectuals always held the Japanese in contempt, but the terrible behaviour of the Japanese soldiers in China has created an intense hatred amongst all classes, and it will live for many years. Like the people in Britain, the Chinese "can take it," and their engineers and artisans will work on until the enemy is defeated. Their tenacity of purpose has enabled China to make a steady advance in developing her internal resources; that is much more important than a spectacular military victory.

Before the Burma Road was built the two largest provinces in China, Yunnan and Szechwan, respectively 150,000 and 220,000 square miles in area, were isolated (England is 50,874 square miles in area). It is true that of late years the railway from the coast in Indo-China has connected Kunming (the capital of Yunnan province) with the sea—the railway that "cost a human life for every sleeper laid for miles along the dreaded Nanti valley." There was also difficult water transport up to Chungking, in Szechwan. 1350 miles above Shanghai. It was exciting to make a trip in a British vessel of about 1200 tons register, driven by oil engines of 3500 H.P., through the famous gorges, where the rapids make navigation perilous and where the difference between high and low water each year is about 180ft. There are no British ships operating on the Yangtse to-day; most of them are laid up, and it is probable that the loss is about £250,000 per annum.

These two provinces are on a lofty plateau; Kunming is at a height of 6400ft. In Yunnan there are four arsenals, several power-driven factories—there are 18,000 spindles in operation—and immense mineral wealth—tin, coal, gold, &c. Kunming is 2000 miles from the old centre of government, now called Peiping; the Imperial express took 100 days for the journey. From Chungking to Rangoon is 1500 miles. The journey now takes about eight days by road and rail; this will be improved upon.

Kunming is 600 miles from Chungking. The total length of the road to Laschio, the railhead in Burma, is 772 miles. The Burmese Government built the 124 miles of road in their territory, and at the other end the Chinese Government had completed the 281 miles of road from Kunming to Hsiakuan two years before the outbreak of war. Since the outbreak of war more than 5700 kiloms. of highways have been built in the interior of China, and the Minister for Communications, Mr. Chang Kiang An, recently stated that the vastness

* THE ENGINEER, December 23rd and 30th, 1938.

of the interior of China necessitates a huge fleet of trucks to carry on international trade.

From Hsiakuan to the frontier, 367 miles, the road was built over mountains, 8000ft. high. It passes over two mighty rivers (the Salwen and the Mekong) and countless valleys that make the country look like a toast rack. The gradients are appalling. There are hairpin bends where the road is only 8ft. wide, with a drop of 2000ft. for any vehicle that slips over. A Chinese engineer told me, in a casual manner, "We lose on the average two lorries and three or four men every day on the road, but that is nothing in war." He reminded me that in Yunnan province alone, 10,000,000 lives were lost in the sixteen years of the Moslem rebellion (A.D. 1856–72). There were many more casualties during the Taiping rebellion in the middle of last century, but which did not affect Yunnan.

Of their present affliction, the Chinese say, "This, too, will pass." In a land where flood and famine have periodically taken a toll of millions of lives, and where rebellions have decimated the inhabitants of large districts, calamities are accepted with a stolidity that astounds the English. It is a characteristic due, to a great extent, to a social code which has been observed by the race through many generations, and which insists that the family is of more importance than the individual. Brave and cheerful, industrious and intelligent, but pledged to parentage, the Chinese in his home formerly asked nothing from the outside world, and felt no "national" obligations to that outside. That social system was not likely to throw up natural leaders for a nation, such as the *samurai* in Japan. That is why this intelligent and industrious race seem to be unable to organise any large undertakings. The war and the new methods of communication have, however, unified the nation as never before. It has always been an axiom in China that the people have not only the right, but the duty, to rebel against oppression, and often have they done so. Any Chinese Government must guarantee personal freedom, but to-day it is accepted that it can not only guide but compel.

The Province of Szechwan

Their social system made the Chinese weak in organisation, and so American experts were engaged to organise traffic on the Burma Road. They have effected great improvements. No doubt it is well camouflaged in the difficult country through which it runs. The Japanese will bomb it, but my inspection of craters in South China showed me they are poor marksmen. And the Chinese have huge labour battalions ready to make repairs.

Szechwan, now the home of the Chinese Government, is about twice the size of Britain and has a population at least equal to that of Japan. A tremendous influx of refugees from the Yangtse Valley has enormously increased the numbers. Many of the refugees are skilled artisans and engineers. A great amount of machinery was carried up into the province in advance of the Japanese tide up the Yangtse River. With abundance of cheap labour, it is being used, not only for military purposes, but to utilise the great variety of raw materials in the province. For Szechwan is rich in many things—foodstuffs, such as rice, wheat, maize, sugar, and oranges; minerals, such as iron, copper, salt, coal, and gold; textile materials, such as silk, wool, and hemp. A great quantity of wood oil was exported; much of it was carried in bulk in ships down the river to Shanghai. Some of the immense wealth of metal in Yunnan province—gold-bearing copper, the zinc of the Kungshan coalfield, and silver-bearing lead—was carried by coolies and animals, and later by motor trucks, to markets in Szechwan.

As long ago as 200 B.C., Chinese engineers provided a remarkable irrigation and flood-prevention scheme in Szechwan. It transformed the Chengtu Plain from waste into fertility, an area equal to that of Middlesex. Ten years ago the population on the plain was ten times as great as that of the English county, but the great influx of refugees has added to the numbers there.

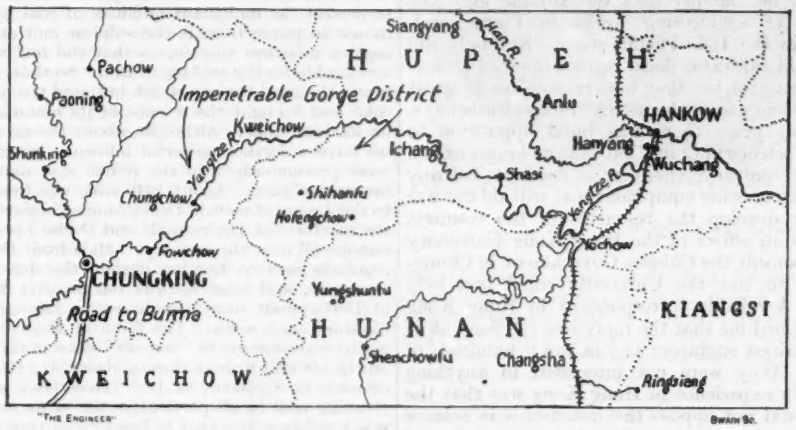
Transport in South-East Asia

Last year it was my good fortune to travel some thousands of miles by motor through French Indo-China, Siam, and Malaya. Visits were also made to Manilla and Java. It was surprising to find such excellent motor roads in all these places, and to be told of the recent advances in modern methods of transport. Public vehicles were crowded.

The French engineers had done good work in Indo-China. One of them told me of a large reclamation scheme on the coast which had been recently completed. He stated that the land reclaimed had provided work, mostly on ricefields, for so many people that 3,000,000 human beings were living on an area which previously was entirely uninhabited.

French scientists had also been at work and had done a great deal to make the country a centre of interest to Europeans and a more prosperous home for the natives. No engineer could visit the famous city of Angkor without feeling immense admiration for the constructive ability of the builders of the temples and palaces of ten centuries ago. For about 300 years a million people lived in the City of Angkor, and then it was suddenly deserted; no one lived within a hundred miles of it, and no one knows why it was deserted. Europeans had never heard of it until at the end of last century the French discovered it, buried in the jungle, which has reduced to ruins many of the huge stone buildings. But the French have restored the vast temple called Angkor Vat, certainly the most fascinating building it has been my lot to inspect. When, after a 300-mile motor ride from Saigon, over excellent roads, but under the heat and glare of a tropical sun, we reached Angkor, we met an acquaintance, a shrewd Scotch banker who had travelled all over the world. He had just returned from a visit to Angkor Vat. "Let me come with you to see it again," he said. "You are an engineer, so you ought to be able to explain to me how they erected a building higher than Notre Dame, built only of huge stone blocks, and standing through nearly eleven centuries, without any mortar or cement to hold it together." Then, after a pause, he said: "Well, I have been disappointed when seeing many of the sights of the world, after reading about them in the tourist books, but, believe me, there is no baloney about Angkor—it beats any description!"

The building is now in a good state of restoration. It was probably saved from the encroachment of the jungle, which ruined so many other fine works, because it was surrounded by a moat. It is rectangular in shape, and on the ground floor is a wide corridor, with walls built up of large stone blocks placed one on top of the other. You can walk round the four sides of the rectangle, along this corridor, the total length of which is 2·2 miles! And you can climb up the many stone steps to the *sanctum sanctorum* on the third storey of the temple. "Tell me how they got that huge coping stone, that forms the roof, up here," said the banker. The answer was that an enormous earth ramp must have been provided for the purpose. The quarries whence came the large rectangular stones that, piled one on top of another, made up this amazing temple, were several miles away, and the stone must have been floated on ratts down the river. It is strange that few Europeans in the Far East have heard of Angkor, and on my return to England it was noticeable that none of my friends had heard of it. Indo-China is but a name to most people in this country, but it meant much to the many French people there, amongst whom were engineers and scientists, pushing forward the new type of peaceful civilisation into Asia. We cannot believe that their work has been in vain. The Japanese have obtained possession of the railway from Hanoi, on the coast, to the Chinese frontier. A few months ago they bombed the end of one of the tunnels, and a train, containing amongst the many passengers several Europeans, was wrecked and everyone on the train was killed. Chinese engineers, with as many coolies as they wanted, made a new tunnel and had the line running again within a month.



MAP OF WESTERN CHINA

Water and Road Transport

Between the great mountain system in Asia and the seas to the south and east—the Indian and Pacific oceans—there is an immense granary, whose economic strength has not yet been fully developed, and that is awaiting the spread of knowledge concerning applied science in order to yield its tribute to mankind. And in that area 48 per cent. of the world's total population is concentrated on barely 5 per cent. of the land surface of the earth!

To the north and north-west of the high mountain ranges is the background of the vast Arctic-Atlantic hinterland, with its endless leagues of steppes flanked by a huge area of primeval forests. Centuries ago some 200,000 horsemen, intent on looting the rich plains to the south of China, found their path blocked by that marvellous structure, the Great Wall. The horsemen recoiled, like the waves of the sea stopped by a cliff, and they dashed across the many thousands of miles of Asia, right up to the walls of Vienna. Thus did the Chinese engineers who built the wall bring the Turks into Europe. The reaction came with the development of applied science, and especially since the invention of the steam engine, accelerated the rise of ocean power and enabled engineers to make travel by rail easy, rapid, and safe. Calais and Hong Kong in South China were connected by rails that run through the tropics, Siberian forests, across Asia and Europe, connecting the Pacific Ocean with the English Channel. Many thousands of miles of railways and motor roads were built. The old single-file caravan tracks, with their tens of thousands of human and animal bearers, slowly carrying goods between trade centres, have been converted into modern highways. By air, passengers and mails have been carried from Hong Kong to London, from Hong Kong to Chungking and other remote cities in China, and from Hong Kong across the Pacific to San Francisco.

In Asia Nature has developed certain features on a gigantic scale, but there is room for them. There are abrupt contrasts between the comparatively small swarms of raiders of great mobility in the north and the remarkable concentration of humanity, 48 per cent. of the world's population, between the ramparts of the great mid-world mountain system and the Indo-Pacific Ocean. On the one side, virility; on the other, there seemed to be deceptive immobility, brooding over Hinduism and Buddhism, creeds of calm and contemplation.

India was the first part of Asia to be affected by the work of the engineer, and, whatever may be the political and social changes in that land, there will always remain many monuments to commemorate the devotion of British engineers to a sense of duty.

Burma and Siam presented greater obstacles to engineers than India; obstacles of a political type rather than technical difficulties. But there has been progress. In recent years the Japanese have put forward a scheme which at first sight seems attractive, but which presents enormous engineering difficulties. It is to cut a canal across the Kra Isthmus in Siam. It would save 600 miles of sea travel between Calcutta and Canton, and at least 1200 miles between Rangoon and Bangkok.

My tour in Malaya last year made me realise that the notable economic progress in that country had been very largely due to the work of engineers.

Everywhere there was evidence of the determination of the Government to do everything possible, so that the country should benefit by improved methods of communications and engineering schemes of all types. It was typical of the enterprise of Government officials in Malaya that we travelled in air-conditioned railway carriages—a very great relief in a tropical country. Malaya supplies plenty of evidence, as do Hong Kong and Shanghai, of co-operation between Chinese and British.

Chinese Engineers and Scientists

Mechanised transport, ships, motor-cars, trains, and aeroplanes enabled us to travel thousands of miles along the coast line, through cities, villages, rice fields, rubber plantations, and jungle in this fascinating part of the earth. In the evening we listened to the B.B.C. news relayed from the Hong Kong wireless station, and we knew that they could hear it in many parts of China. We found that the English language could be understood in nearly all the places we visited. It seems inevitable that the vast experience that Anglo-Saxon engineers have gained in tropical lands (India, Africa, and America) will be applied in this part of the world.

About thirty years ago a number of us listened to Dr. Diesel at a meeting of the Institution of Mechanical Engineers, when he outlined his belief that the British would utilise tropical soil for the production of vegetable oil suitable for the production of power. When we saw the rather crude mechanism installed on the palm oil plantations in Malaya, where they obtain quite large quantities of oil for human consumption, the vision of Dr. Diesel came to my mind, and it often returned as we rode in comfort through the jungle. Under the tropic sun Nature accelerates the reproduction of vegetable, insect, and animal life in a manner that at first bewilders the native of the temperate zone. It seems that the earth and the fulness thereof have been placed at the disposal of man, but that *homo sapiens* has, so far, miserably failed to make good use of the good earth and the sun.

The contrast between many of the natives of South-East Asia and the Chinese who had emigrated to the south made me realise that Nature abhors indolence even in a land where a man can exist on a few handfuls of rice and the fruits dropped from the trees. Starvation is easily defeated, but malaria, enteric, and other preventable diseases each year claim millions of victims. Indolence leads to decadence. Many of the natives, and some Europeans, live as if "there aint no Ten Commandments," and pay the inevitable penalty, for which the climate is too often blamed. The poverty-stricken Chinese emigrants, on the other hand, are the most active workers, pulling through hardships that would kill the average European, demonstrating that work will win and that the meek—and energetic—accumulate wealth. These Chinese ex-coolies are the millionaires and ideal citizens in Malaya, Siam, and Indo-China. They were taught from infancy the Confucian code that man is capable of great development provided that he follows the moral code taught by his elders and betters.

An Englishwoman who travelled over the Burma Road in a lorry wrote: "I sat down to consider my revolutionised ideas of the Chinese. True, my knowledge of them was extremely slight, gleaned from hearsay, books, and casual acquaintance with members of the race in other parts of the world; but nothing I had learned had prepared me for their amazing kindliness, their attention to practical detail, their strong sense of humour." My own experience makes me re-echo those words.

The wealthy Chinese emigrants remain loyal to the Confucian code. They train their sons to respect their elders, their teachers, and to remember the old axiom that of all men the scholar stands highest in social status. They accept another ancient axiom from their classics, viz., that people should be governed by moral and intellectual agencies rather than by physical force.

There are many young Chinese men and women who are seeking the new knowledge in European and American universities, but they know the Confucian code. You see the results in the struggle made by the Chinese graduates to build roads and communications of all types. They have installed power plants and opened up mines. They are at work on the new hospitals—my friend, Dr. Ling, was running a hospital on the Burma Road when last we heard of him. They are teaching the laws of hygiene; they are trying to improve agriculture, and to urge the importance of scientific research. Perhaps some are attracted by certain Western political and economic theories, much of which will not fit into the Chinese social system. But make no mistake, there is the same dynamic urge to do useful work that brought wealth to their fathers in a land waiting for development. The Japanese military caste fear the results of scientific knowledge and methods in China and have made great efforts to bomb the modern universities. They have not succeeded in preventing instruction in applied science subjects in China, and even if they did there are the millions of overseas Chinese, many of them wealthy, who are urging their sons to qualify as engineers, doctors, &c., so that they may return to China or work in South-East Asia.

Mention must be made of the Malay islands—Java, larger than England; Sumatra and Borneo, much larger; Celebes, and numerous other islands—these are the lands for which the English and Dutch fought each other so bitterly in the seventeenth century, and where it seems probable they will closely co-operate for the development of their natural resources at no distant date. What opportunities for the engineer and scientist are offered by these fertile areas: Already the ubiquitous Chinese have done much of the commercial development. Some of our Hong Kong engineering graduates returned to Java, Sumatra, or Borneo, and we heard of them installing power plants for sawmills, cold storage, &c., or engaged in surveys of the jungle. There are schools in this area where the Chinese are trained in English up to matriculation standard.

It can be claimed that the British were the pioneers of engineering works in China, and, indeed, in the Indo-Pacific areas. Not only did they build railways, docks, and industrial power-driven factories, but they were responsible for great improvements in harbours and inland waterways. For many years there was blind opposition to Western science in China, but that no longer exists. On the contrary, there is a demand for any machinery or other equipment that will aid the war effort or develop the resources of the country. Recently an officer of the Hong Kong University flew to consult the Chinese Government in Chungking, as to how the University could best help China. A reliable correspondent in Hong Kong has informed me that the reply was: "Send us as many trained engineers as you can; hundreds of them." They were not interested in anything else! My experience in Hong Kong was that the Chinese did not oppose the instruction in science of their own nationals, but that a number of English residents, particularly graduates of Oxford or Cambridge, who had studied classics, did their utmost to prevent any extension of the engineering departments. They did not hesitate to inform me that engineering was not a fit subject to be included in a university course. There should be, they said, a technical school unconnected with any institution that confers degrees. During my service in the universities of Birmingham and London in the early part of this century, my colleagues in the Faculty of Arts often expressed those views—in a very pleasant manner—but which left the impression that they believed that engineers were out of place in the academic cloisters, which, they said, should be preserved for those concerned with ideas which do not affect things material. It was useless to talk to them about the ideals of engineers; all of the evils of the industrial system were attributed to the inventors of machinery. That spirit still exists in England. Only a few days ago an Oxford professor solemnly stated in my hearing, in the course of an address, that the war was caused by wireless, because Hitler would never have attained to such power without the aid of that invention! There are perhaps men of the Mandarin type of mind in Britain, as well as a few in China. It is significant, however, that the Chinese Government, in this crisis, is doing everything possible to encourage engineering developments.

It is not only the Burma Road that is of interest to those British engineers whose thoughts are turned to the Far East. We see in the conference at Delhi evidence of co-operation between India and the rich tropical countries in the Pacific. We can be sanguine that at no distant date there will also be co-operation with the Chinese. In the last war the Chinese labour battalions in France did splendid work. It is not improbable that in this war we may seek the aid of Chinese labour and co-operate much more closely with the Chinese Government. It is my firm conviction that the Chinese work more harmoniously with British people than with any other nationals. It has been stated that there are 3,000,000 Chinese who have British nationality and who reside in Malaya, Hong Kong, and other parts of the British Empire. In the days of reconstruction it will be to the mutual advantage of both nations if they can co-operate in the economic development of South-East Asia.

The Production of Coke*

Coke, in the form and character of its present-day production and the diverse uses to which we now apply it, might be termed a new fuel and a new industry which has grown and developed largely within the last twenty-five years, yet history vaguely suggests that coke was used as an article of commerce some 2000 years ago by the Chinese, although there is nothing to verify this, and we get to the Middle Ages before we can discern the beginning of deliberate coke manufacture when it is clearly ascertained that Julius, Duke of Brunswick, recommended the coking of coal in 1584. English records have it that coke was made in the Middle Ages principally by blacksmiths for the working of iron; they reduced coal so that it was brought to a resemblance of charcoal, which was the fuel used for metallurgical work at that time. The scarcity of wood for charcoal making and the increasing demand for iron stimulated investigations for its substitution by coke. We have quite considerable evidence of the necessity to make this substitution and it is on record that the Scottish Parliament in 1609 passed an Ordinance restraining the use of wood for iron smelting because timber was so largely needed for other purposes, primarily for the building of ships.

In 1620 the Patents Office records that Patent No. 15 was granted to one Hugh Grundie and others to correct the malignant qualities of coal by special means to purge from it the sulphur and other contagious mixtures therein, so that the fuel would be serviceable for the making of iron. So that, in effect, it was the need for iron which initiated the making of coke and brought the science of its manufacture to its modern stage. Although, about the same period we have a further powerful influence bringing coke most prominently into the public eye, namely, the brewing of beer. About 1640 coke was first applied to the drying of malt in Derby, and so important were the results that Derby malt and Derby beer became famous all over the country. Malt from Derby was regularly sent to London despite the difficulties of transport, and later records tell us that 200 loads of Derby malt were also taken to Lancashire and Cheshire each week. The fame of Derby malt led to the manufacture of "hearth" coke in other areas, and in 1663 Sir Robert Murray, describing this making of malt in Scotland, said: "They have a way of charring coal in all particulars the same as they do wood, whence the coal is freed from those noxious steams that would otherwise give the malt an ill odour."

The method of producing the coke in those days was probably developed by the charcoal burner, who set large coal in heaps and banked it with coal dust, a crude method of coke making which was continued probably for over 200 years, and Dud Dudley, a man well known amongst the iron workers of those days, was popularly accredited with the greatest success in substituting coke for charcoal in iron smelting, although the credit for the successful use of coke for this purpose probably and more properly belongs to Abraham Darby, of Shropshire, whose successful application dates from about 1735.

It was not until 1750, however, that the first coke blast-furnace was built in Cumberland, by John Cookson. By degrees others followed Cookson's lead, and, due to a rapidly increasing demand for iron, it is evident that the success of the coke blast-furnace was fully established by 1790, by which time there were eighty-one in operation throughout the country.

What great changes have taken place in the coke oven industry and the manufacture of coke since those days! Yet the greatest development lies entirely within the last twenty-five years. Before that time mechanical handling of the coke after discharge was almost unknown, and it was lifted by hand into railway wagons. The construction of coke ovens at that time made it impossible to heat them uniformly, so that the coke manufactured was uncertain in its composition and lacked uniformity of size and structure. The great mechanised plants, with which we are familiar to-day, had not begun to be built in this country until after the last war, so that the intervening years have seen the size of the by-product oven grow to its present dimensions. We have seen, too, mechanisation carried to such a degree that the number of men required to operate a battery has been reduced, per ton of coke, to a very small fraction of the number required in 1914. The heating of coke ovens has been improved out of all recognition, and scientific instruments have been applied to control its manufacture which hitherto had not even been envisaged.

There was then little realisation of the importance of the character of the coal that was to be carbonised,

* From a paper entitled "Some Thoughts on Coke," by W. L. Boon, M.I. Mech. E., presented before the Institute of Fuel, on October 8th.

and it was the practice to put into the coke oven whatever rubbish for which the colliery had no other use. To-day, we recognise that the quality of coal is of fundamental importance, and that the characteristics of the coke and its value in use are profoundly affected by careful selection of the coals to be carbonised.

We have not yet progressed very far in the science of blending coals, although blending is becoming common practice; not only the blending of different coals, but of coal with coke breeze; and more attention is being given to the preparation of these mixtures before carbonising, so that coke of the correct quality and structure may be produced for the purpose for which it is to be used. There is a wide difference, for example, between the characteristics of coke required for the blast-furnace and cokes produced specifically for domestic use.

In the old days coke was produced, and one used it as far as one was able to do so; to-day it is manufactured for the purposes for which it is specifically required. There is no comparison therefore between the so-called cokes of twenty-five years ago and the exact fuel produced to specification, which yet (perhaps with some disadvantage) retains the name of "coke." These remarks are true whether the coke comes from by-product ovens or from gas-making retorts; and whilst great strides have been made in the improvement of coke quality, there is every indication that improvements in this direction will continue when peace-time conditions of coke production allow progress to be resumed.

In the last decade we have seen many significant changes in the coke-producing industries, one of the most outstanding perhaps being the convergence of development of the coke oven industry and the gas industry. These two industries, producing about equal quantities of the total coke made, and now carbonising in the aggregate nearly 40 million tons of coal per annum, have come together in two major directions—first, in the marketing and utilisation of their coke products, and, secondly, in the purchase and utilisation of coke oven gas. Also, the two industries have arranged common action in the marketing of benzol, sulphate of ammonia, and tar, so that there is a close business alliance which did not exist, and had indeed no reason to exist, before the last war.

We have seen a further important movement in the coking industry which has a significant bearing on the production of coke for the general market. During the last ten years there has been a great reconstruction of the British iron and steel industry, in which works have erected their own coke ovens and are utilising or are preparing to utilise blast-furnace gas, coke oven gas, and even coke within their own works. The effect of this is to make the whole of the steel industry self-contained and independent of its requirements of blast-furnace coke, which in earlier years it had purchased from the colliery coke ovens. This development has already assumed large proportions, and the day is probably not far distant when the great bulk of the coke requirements of the steel industry will be satisfied from its own coking plants. This development must be recognised as a process of rational integration, providing for commercial and technical stability and for greater efficiency in steel production, but it will have the effect of directing colliery oven coke increasingly to other markets, to be used for purposes other than the manufacture of iron and steel. The purposes for which it may then be used embrace almost every type of heat application for which solid fuel can be utilised, so that coke production from the colliery coke ovens must develop exactly in the same markets and be used for the same general purposes as gas coke. This position is being wisely determined by the two industries who have recently set up joint associations, agreeing on marketing methods and co-ordinating development, so that instead of the old evils of competition between the two industries, we can envisage progress on co-operative lines and under sane economic conditions.

It can be said therefore that the trend of development which has now been instituted by the coking industries appears to be on sound foundations, and if the progress which this unity of purpose promises is fulfilled, both commercially and technically, there would be no reason to doubt its future prosperity.

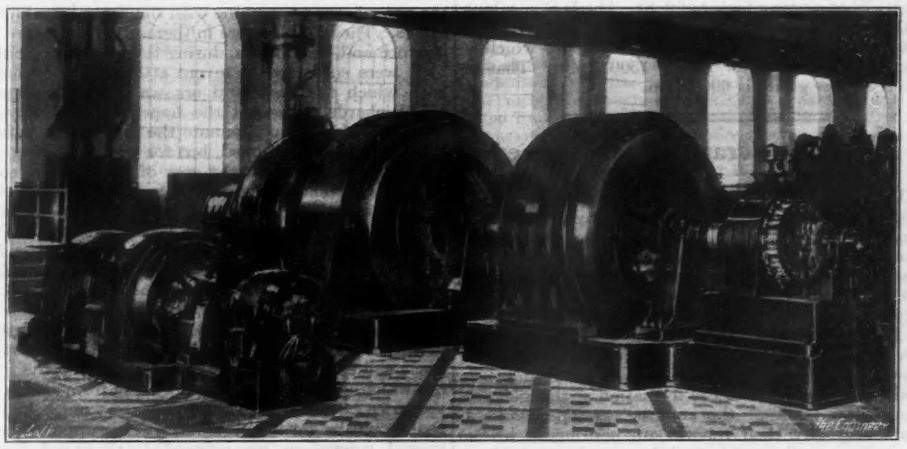
There is no room, however, for complacency with regard to the quality of coke which the two industries are producing, and as market development must be progressive, coke quality must be kept in step with it.

If one may forecast what the future holds in this connection, I would say that the quality of coal used for coke making will receive first consideration, whether it be for the production of blast-furnace coke or for coke made by the gas industry. Particularly for home markets, higher grade cokes must be produced and low-ash coals will become essential for this purpose. We see already clear indication of this demand in the coal-cleaning policy which is being followed by coal producers, and we can envisage still further progress towards improved standards of coal cleaning. We shall require coal into coke ovens or into gas retorts as free from inorganic material as the modern science of coal preparation and treatment can devise.

The art of coal blending and/or of coal and coke admixture before carbonisation has obtained most important and encouraging results, and there should be no question that research will continue in this direction. We may envisage, too, the treatment of coke after carbonisation for specific purposes. The domestic market in particular is insistent in its demand for improved quality in fuel, and, to keep pace with its demands, we must contemplate many changes in the future and the adoption of a progressive policy in interpreting and perhaps keeping ahead of the consumers' requirements.

Interconnection of Three Different Networks

An interesting solution of the problem of interconnecting three supply networks of different current characteristics was provided for a steel works in the East of France by Alsthom, shortly before the German "blitzkrieg." One of the networks, known as the "supply" network, was the ordinary three-phase French grid. The second, known as the "plants" network, was also, in theory, a three-phase, 50-cycle network, but instead of being fed from turbo-alternators and converters, as is the grid, it was fed by gas-driven generators so that both the voltage and frequency were subject to frequent and considerable variation. Finally the third network involved was a D.C. supply. What has happend to this plant since its installation we do not know, but for the purpose of this article we assume it to be still in existence.



PLANT FOR INTERCONNECTION OF THREE NETWORKS

Exchange of power between these three networks is provided for by means of three rotary machines on a single shaft, as shown in a half-tone engraving, any of which may act either as a motor or as a generator as the conditions on the networks may require. The accompanying diagram shows how the connections have been made. In this diagram MS represents a synchronous machine connected to the "plants" network, MA is an asynchronous machine connected to the "supply" network, and MD is a D.C. machine. The capacity of these machines is so calculated that MA has a capacity equal to the combined capacities of the other two. By suitable regulation of the whole group it is possible to obtain any desired exchange of current between the three interconnected networks in spite of their dissimilar current characteristics.

This regulation is provided by an independent regulator group, designed to feed the rotor circuit of the asynchronous machine MA with a tension which is regulable in value and direction, and at a frequency equal to the phase displacement in the machine MA. For this purpose the secondary circuit of the asynchronous machine MA is connected by means of its slip rings to the terminals of a generator Mc, which is on the same shaft as a synchronous motor Mx which serves to drive it, and which is fed by the current of the network to which the asynchronous machine MA is connected; that is, by the "supply" network.

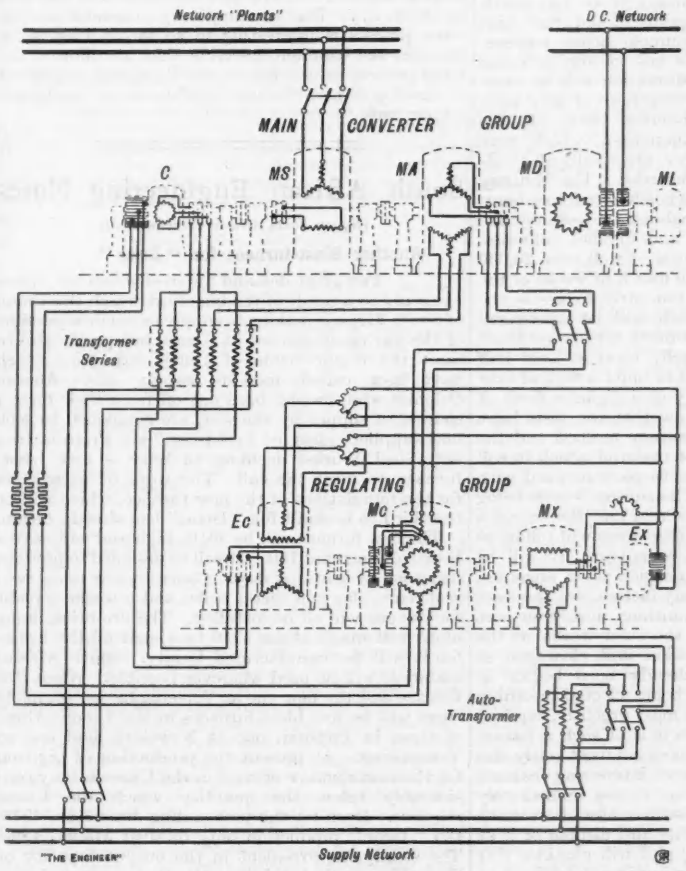


DIAGRAM OF CONNECTIONS

The generator in question Mc is of the collector type and provided with commutation poles and with a neutralisation winding in the stator. The latter is connected in series with the armature winding. The result of this arrangement is that the neutralisation winding sets up a field equal and opposite to that of the rotor, so that tensions induced by the pulsations of the current in the stator and in the rotor will compensate each other. The actual output of the machine therefore will be a current having the same frequency as that used to excite this generator, and constantly in phase with it. This means that the generator Mc is in reality only an amplifier, serving to step up the excitation current fed to the machine.

Excitation is from an alternator Ec on the same shaft as the generator Mc and the driving motor Mx, and having the same polarity as this latter. Two excitation windings are provided on this alternator arranged at 90 deg. in phase from each other and each fed from an auxiliary exciter Ex through a potentiometric inversion rheostat. This arrangement makes it possible to vary the value and phase of the output current of the exciter alternator progressively and as desired.

The output current of this exciter alternator is compounded with the secondary tension provided by a series transformer, the primary of which is fed by the current running to the asynchronous machine MA, and the resultant is fed to the slip rings of a frequency changer C on the same shaft as the three machines of the main converter group. This frequency changer is wound with the same number of poles (ten

in this installation) as the asynchronous machine, and it transforms the current fed to it into a current of a frequency exactly equal at all times to the phase displacement in the asynchronous machine operating on the same shaft. Since this is exactly the type of current which is required to feed the rotor circuit of the asynchronous machine MA, it can be used to excite the generator Mc which provides this feed.

Principal characteristics of the various machines of the system are as follows:—The asynchronous machine MA is built for a tension of 5 kV ± 5 per cent. The "supply" network to which it is connected has a normal frequency variation between 49·9 and 50·1 cycles. Operating as a motor, this machine is capable of providing a power equivalent to 2200 kW at a power factor of unity. Operating as a generator, it can supply up to 2300 kVA to the supply network.

The synchronous machine MS is designed for 5300 volts. The plants network to which it is connected has a normal frequency variation from 49 to 51 cycles, and the possibility of exceptional variation from 48 to 52 cycles. Operating as a motor it is capable of providing power equivalent to 1100 kW at a power factor regulated to unity, and as a generator it can supply up to 1250 kVA (equal to 1000 kW at a power factor of 0·8). The D.C. machine MD is built for a power of 1000 kW at a tension of 250 volts. The speed of this whole group, which is started up by a motor ML is 1500 r.p.m. That of the regulator group is 600 r.p.m.

National Scrap Metal Survey

THE National Survey of the Ministry of Supply Iron and Steel Control for the recording of fixed and demolition scrap iron and steel, launched on September 24th and referred to in our Journal note of September 27th, is proving completely successful. It will obviously exceed even the expectations of its organisers, both in the tonnage of material located and in the loyal and indefatigable work of the local government officials. Surveyors and Sanitary Inspectors throughout Great Britain are giving their enthusiastic support to the formation of this gigantic Doomsday Book of the country's scrap resources, and every day their reports are pouring in to the Control revealing old buildings, mines, bridges, machinery, railway track, and a host of derelict structures containing thousands upon thousands of tons of much-needed scrap metal. From the moors surveyors are reporting long-forgotten steel towers and overhead wires, old sections of track leading into old workings and covered with undergrowth are being uncovered and assessed. Derelict buildings of every type are being reported and their metal tonnage assessed. Railways which were originally laid by German prisoners during the last war and which have for many years been idle have now appeared in our records. Buildings which have been destroyed by enemy action will shortly contribute their twisted girders and ironwork to our furnaces. We are learning of ancient tin and other mines which have been covered and grass grown for many years, but which may now contribute their quota of old rails and similar scrap metal. Old pumps, beam engines, windmills, water wheels and a host of similar items are also being revealed, but discretion will be exercised so as to avoid the destruction of any such objects which have a rare historical value. In the counties of Somerset and Glamorgan, which were chosen to commence the survey, practically all available material has now been recorded. The Ministry of Mines has also given its wholehearted collaboration and its inspectors throughout the country are surveying abandoned mines and derelict collieries. The work has resulted in a total of well over 20,000 tons being recorded during the first four weeks of the test survey, and while it is too early to assess the probable total resources which will be discovered throughout Great Britain, the officials responsible are confident that it will eventually total at least half a million tons—sufficient steel to build a fleet of over 300 destroyers for H.M. Navy or a gigantic force of 7000 heavy Army tanks. Now that the tests have proved the efficiency of the survey method and the probable tonnage and type of material which it will reveal is known, it is planned to press forward with the survey in other areas. The survey is now being extended to the whole of Scotland and the counties of London and Middlesex; other areas will follow as rapidly as the work can be organised. It will be appreciated that the order in which these areas are chosen is dependent upon many factors, not the least of these being scrap dismantling and transport facilities, plus the needs of the steel works in the immediate vicinity. Demolition and clearance of the survey material has already been begun in several areas. The material is being selected according to the type of metal which is most urgently required by the steel works and where it is of such a nature that it can be collected and recovered most easily and economically. One of the most interesting features of the survey is the fact that it has immediately stimulated many owners of such material to make their own settling arrangements and dispose of it at once. This trend is growing and will continue; it will cause an invisible but very important addition to the resultant figures.

Sixty Years Ago

THE THOMAS AND GILCHRIST PROCESS

IN a leading article in our issue of November 19th, 1880, we asserted that the hopes of Cleveland were centred at the moment in Mr. Windsor Richards, the manager of Bolckow, Vaughan and Co. On him, we said, the success or failure of the Thomas and Gilchrist basic process of steel making depended. Mr. Richards had just addressed the Cleveland Institution of Engineers on the subject. The information which he had to give concerning what was being done at Eston led to the conclusion that the process was a metallurgical success as applied to the phosphoric Cleveland ore, but that its commercial success had yet to be proved. Mr. Richards gave no figures concerning the costs of producing basic steel in a Bessemer converter, but we argued that they must clearly be much higher than the costs of producing acid steel. The lining of the converter had to be made of lime bricks instead of ganister (silicon) bricks. After the carbon, silicon and most of the sulphur had been eliminated in the usual Bessemer manner an "after-blow" had to be given to the charge to cause the phosphorus to combine with the lime of the lining bricks. Those bricks were in themselves expensive to produce and, in addition, during the early part of the blow were subjected to severe attack by the silicon with which the Cleveland ore was highly charged. Mr. Richards expressed the hope that one day it would be possible to eliminate the phosphorus before the carbon flame dropped, but for the time being, in order to economise on the cost of relining the converters with lime bricks, he was reduced to using two converters. The first converter was lined with ganister and in it the silicon was eliminated. The metal was then poured into a lime-lined converter for the elimination of the phosphorus. Such a double process, we argued, could not possibly compete in cost with the single process followed in the case of acid steel production. The basic process, we reported, had been adopted on the Continent with, it was said, great success. If that were so, then either the iron ore which was used was tolerably free from silicon or the price obtained for the product was much higher than could be got in this country. In support of the second suggestion we referred to a recent order received by a French firm for basic steel rails at a price of £6 15s. per ton. At the same time an English firm was glad to receive an order for 10,000 tons of rails at £5 10s. per ton. At the French price it would, we said, be quite possible to pay for the relining of the converters very frequently and yet earn a good profit. At the English price nothing but the most rigid economy would permit a profit of more than one or two shillings per ton to be realised. The fact that the basic process was profitable on the Continent did not prove that it would be profitable at Cleveland. We must, we said, suspend judgment. It would be rash to prophesy either success or failure, but in six months we would know the truth. If it were possible to make the process a commercial as well as a metallurgical success, Mr. Windsor Richards was the man to do it. . . . This contemporary comment on the basic process is interesting in so far at least as it disposes the common assertion that we allowed the basic process to develop on the Continent and failed to develop it here through indifference or negligence on our part.

South African Engineering Notes

(By our South African Correspondent)

Another Blast-furnace for "Iscor"

THE great demand for steel which has arisen—mainly as a result of the big effort which the Union of South Africa is making to supply as much as possible of the war equipment of its forces, but partly also to meet the requirements of Union industries which have been called upon to supply other African Colonies who, having been cut off from their former sources of supply by the war, are compelled to seek new suppliers—has led to "Iscor," the Pretoria Iron and Steel Works, deciding to erect a new blast-furnace to meet the call. The work of excavation for the foundations of the new furnace, which will be the third to be built for "Iscor," has already begun.

The new furnace will be 86½ft. high and will have a hearth diameter of 16ft. It will be designed to produce 600 tons of metal a day. Concrete ore bins, two-scale cars, slag and metal ladles and a washing plant for the gas will all be installed. The fire-brick lining alone will weigh about 1150 tons, and all the bricks for it will be manufactured locally. South African materials will be used wherever possible. When this furnace and the new one at Vereeniging are complete there will be five blast-furnaces in the Union—three of them in Pretoria, one at Newcastle and one at Vereeniging. At present the production of pig iron for the manufacture of steel in the Union is very considerably below the quantity which the Union requires. Even for the year ending June 30th, 1938, the "Iscor" production only totalled 344,267 tons. The steady improvement in the output capacity of the rolling mills has been such that a much larger tonnage can be rolled than is now available, and in order to increase the ingot output and to reduce production costs it has been decided to install a converter plant to work in conjunction with the open-hearth furnaces under the duplex process. This has now been brought near completion and will give an additional ingot output of about 100,000 per annum, necessitating full production on the two blast-furnaces. As this will require a considerable increase in the coke requirements, the erection of a second coke oven battery of forty-five ovens, capable of an output of about 200,000 tons of blast-furnace coke per annum, was proceeded with simultaneously and if the war does not affect deliveries should now be soon completed. When all the additions to the "Iscor" Works are completed and the new works planned for erection at Vereeniging have also been brought to production their outputs, plus the output of the Newcastle blast-furnace, should exceed one million tons per annum, and will probably suffice to meet the normal requirements of the Union as estimated for the present, but when the possibilities of growing demands from the British, Belgian and French African Colonies are examined it seems likely that a further and considerable expansion of the steel-making industry of the Union will have to be undertaken a very few years hence.

Great Irrigation Dam

The building of the Kalkfontein irrigation dam has just been finished and when its 90 miles of canals have been cut, the Jacobsdal district in which it is situated will undergo a remarkable change. As part of the general policy of the Government of developing irrigation in the Southern Free State, investigations were carried out as regards the best site for a dam on the Riet River, and in 1934 it was finally decided that the Kalkfontein site, some 25 miles north-west of Fauresmith, was the best for the purpose; the building of a rockfill structure was therefore planned and a system of canals from there will irrigate approximately 18,000 morgen—over 36,000 acres—of land between this point and the junction of the Riet and Modder rivers.

Work was begun in July, 1935, with the construction of accommodation offices, &c., and the erection of the necessary plant. At first work was considerably hampered both by the scarcity and quality of labour recruited. It had been intended to use only European labour, but owing to these difficulties this plan had to be abandoned and only natives were employed, except on certain portions of the work.

The dam is the second largest in the Union, Vaaldam being the largest. The leading dimensions and quantities of the dam are as follows:—

Crest level	R.L. 4043
Full supply level	R.L. 4032
Crest length	1040ft.
Crest width	15ft.
Upstream slope	1 to 1·25
Downstream slope	1 to 1·4
Outlet level	R.L. 3970
Maximum height	113ft.
Storage capacity	298,000 acre-feet
Rockfill in dam	270,000 cubic yards
Concrete in slab and toe wall	11,000 cubic yards

The rockfill and slabbing was complete in January, 1938, and a start was made on the driving of an 11,000ft. long tunnel in the upper section of the main canal. At the end of the year 2178ft. of tunnel had been driven and 1566 square yards of concrete lining had been placed. The rate of canal excavation was satisfactory, and in March, 1938, a start was made on the lining. The total quantity of excavation done at that date was 308,335 cubic yards. The scheme is now complete except for sub-canals and will irrigate some 18,000 morgen of land between Koffiefontein and Modder River, extending over the Jacobsdal district along the Riet River. The estimated cost is more than £1,000,000.

The Kalkfontein dam is filling slowly on account of a poor summer rainfall in the last year or so, but it has already conserved about 35ft. of water, which represents less than one-fifth of its capacity. The Government has bought the farm Kleinfontein, which is situated two miles from Jacobsdal. A further purchase is in prospect and it is expected that this area will be converted into a settlement on the usual lines. The Jacobsdal district is recognised as eminently suitable for stock farming. When its irrigation values are apportioned it is likely to achieve a reputation worthy of the large amount in taxpayers' money which has been invested. There appears to be every prospect that the railway line will be extended from the Koffiefontein terminus to connect with the main line from the Cape to Kimberley at a point south of the Modder River bridge, bringing East London 60 miles nearer by railway to Kimberley.

FUND TO HELP RAID VICTIMS.—A fund to provide immediate aid to fellow workers who may become air raid victims has been started by men and women employees of British Timken, Ltd., Birmingham. It is their own idea and is entirely voluntary. Men contribute 6d. a week and women 3d. a week. A large number have joined the scheme. The directors are helping by a direct contribution and by arranging for contributions to be deducted from wages and paid direct to the fund. This is a "first aid" fund designed to provide clothing, meals, and other necessities while new homes are found. A committee, elected by the workers and representing all departments, administers the fund.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

Iron and Steel in the United States

Great activity prevails in the United States iron and steel industry. The production of pig iron and steel is at a high rate, and the raw materials position appears to be comfortable. Scrap supplies are adequate to meet all calls, and it is notable that the supply is in larger volume as a result of Japanese buying having ceased. Quotations, however, are well maintained, and in Pittsburg and Western Pennsylvania rule at 21 dollars to 21.50 dollars, and in Eastern Pennsylvania at 19.50 dollars to 20 dollars, d/d buyers' works. It is reported that Mexico is negotiating to sell about 18,000 tons of scrap to England. Some apprehension is felt as to whether the supplies of scrap in 1941 will be sufficient to meet the steel industries' requirements. As a large part of the industry is engaged upon war work it is thought that the output of scrap from industrial construction, &c., may decline. A large proportion of the automobile industry will be taken over by the Government and supplies of scrap from that source are likely to be much restricted. The production of pig iron has increased, but the output of the blast-furnaces East of Pittsburg is reported to be going into direct and immediate consumption. In one case a steel works has taken the entire production of a neighbouring merchant furnace to supplement the output of its own furnaces. No official statement has yet been made regarding prices in 1941; but for the fourth quarter of the current year quotations are unaltered at: No. 2 foundry, 24 dollars; bessemer, 25 dollars; and basic, 23.50 dollars f.o.b. Eastern Pennsylvania. As it is feared that some tightness will develop in the coke situation a number of steel companies are building additional by-product coke ovens, and most of this new production will be in operation late in 1941. The production of steel now stands at an average of 94·9 per cent. of ingot capacity, and some steel works are said to have reached 110 per cent. In Chicago the steel mills are operating at 90 per cent., and at Birmingham at 97 per cent. The sheet mills are operating at 75 per cent., but the tin-plate mills at no more than 45 per cent. of capacity. The works producing structural steel and plates are reported to be booked to capacity for two months, and it is expected that a system of Government priorities will be put into force. Export business has been brisk of late, and Brazil has placed contracts to the value of 9,500,000 dollars with the General Electric Company and Westinghouse Company for the electrification of a railway in the San Paulo Estate. The Argentine, which has arranged a 20 million dollar credit with the United States Government's Export/Import Bank, is negotiating for steel pipe line and equipment to the value of 10 million dollars.

The Pig Iron Market

A heavy demand for all descriptions of pig iron is maintained, but the stringency which threatened the market a few weeks ago has passed and the position is fairly comfortable in all departments. Users of foundry iron are able to get their full requirements and as a result of recent imports the situation is assured for a long time. The light castings industry is still poorly employed on the whole, but the engineering and jobbing foundries are absorbing full supplies. Most consumers have obtained licences covering their pig iron requirements until the end of the year, but in many cases would have been glad to place contracts for a longer period. On the North-East Coast the foundries are well employed, but little Cleveland iron is to be had, and users are taking good supplies of Midland brands. The demand for high-phosphoric foundry iron has improved somewhat as more of the light castings makers have been put on to Government work; but the call is principally for low-phosphoric iron. Imports of this description have eased the position, but the Control is continuing to scrutinise carefully all applications for licences. It is expected, also, that there will be further arrivals of this class of iron in the near future. The principal users of high-phosphoric iron in Scotland are the light castings makers in the Falkirk district, but most of their supplies are now being drawn from the Midlands. These are adequate to meet all requirements, and the consuming industries are comfortably situated. Large tonnages of pig iron are being taken up by users in Lancashire, although the light castings makers are far from being well occupied. The engineering works, however, are extremely busy, particularly the machine tool makers and the heavy electrical engineers. The hematite market is practically unchanged and consumers do not always find it easy to cover their full requirements since the producers are reluctant to book orders for delivery far ahead. Since the distribution of imported iron, however, there has been less pressure to secure delivery by users, and it is understood that further imports are being arranged. The Control, therefore, is carefully watching the interests of the steel industries, and there is little apprehension now of any shortage developing.

The North-East Coast and Yorkshire

The steel works on the North-East Coast are working at the highest possible pressure and production has been on a heavy scale. At the same time, the requirements of the consuming industries under the stimulus of the war effort are growing and makers find it difficult to keep pace with the demand. All the shipyards on the North-East Coast are fully engaged in building or repair work, and there is not likely to be any diminution in the needs of the shipbuilding industry for a long time. Large tonnages of ship plates are required and the producing works are kept employed at full capacity. There is also an active demand for boiler plates and tank plates as the locomotive builders, wagon builders, and tank makers have a large amount of work in hand. The call for joists and sections is strong, but some of the constructional engineers have finished off big Government contracts and for the time being no equally important work has come to hand. As a result there is a slight decline in the pressure to obtain supplies of steel. A heavy demand prevails for bars of all sizes, and particularly for reinforcing bars. All the re-rolling works are busy and have enough work in hand to keep them going for several months, and with their supplies of raw materials more assured this industry is in a satisfactory position. Large tonnages of small sections, bars, and strip are passing into consumption. Steel production in the Yorkshire district has reached a high level, and the Sheffield steel works are busier than for years past. The demand is principally for basic steel, but there is a growing pressure to secure deliveries of tool and special steels. The heavy engineering industry in this area is employed at capacity and is absorbing large tonnages of steel. A steady flow of orders is reaching the works rolling plates, sections, bars, &c. Although the producers are concentrating principally upon basic steel products, there is an increasing demand for acid carbon steel material which is taxing the resources of the makers.

Scotland and the North

The demand for all descriptions of steel appears as strong as in the early part of the year; in fact, in some sections of the trade consumers' requirements are reported to have largely increased. All the Scottish steel works are operating at capacity and great efforts are being made to increase outputs, large as they have been in recent months. The constructional engineers continue to absorb large quantities of steel, and if some engineering firms are not so busy as they were a short while back the total demand does not seem to be much affected. The pressure from the re-rolling industry to secure semis is unabated, but the position is much more comfortable since considerable imports have been distributed. Large tonnages of railway material, such as rails, tyres, and wheels, and colliery requirements of light rails and arches, are being produced and are passing into immediate consumption. Tube-making steel is also wanted in large quantities, and this reflects the great activity which prevails at the Scottish tube works. The production of the engineers making machine tools is particularly heavy, and the needs of this branch of the industry in the shape of special and alloy steel is a feature of the position. The sheet makers have full order books, and in some instances consumers complain of delays in deliveries, particularly when their orders do not come within the priority classes. Most of the sheet production, however, is for Government Departments. The ironworks are experiencing a steady and vigorous demand and are turning out heavy tonnages of bars. The rivet, bolt, and nut makers are large consumers, but the wagon builders, also, are taking good quantities. In the Lancashire market some easing in the demand from the constructional engineers is reported, but there is considerable pressure from consumers anxious to obtain supplies of bars and plates. Boiler, tank, and locomotive makers are amongst the chief consumers, and all these departments of the industry are likely to be fully occupied for some time. In some departments of the Lancashire steel trade there have been complaints of a shortage of skilled labour, but for the most part the works are operating at capacity. The Lancashire heavy electrical and machine tool industries are exceptionally busy.

Steel Sheet Prices

The prices of black and galvanised sheets given in the Second Schedule to the Control of Iron and Steel (No. 13) Order, page 475, are maximum delivered prices for lots of 4 tons and over. The following table shows the controlled maximum delivered prices for all quantities of sheets of basis quality and specification until further notice :—

Delivered England and Wales

	Galvanised corrugated, per ton.	Galvanised flat, per ton.	Black flat, per ton.
	£ s. d.	£ s. d.	£ s. d.
4 tons and over :			
Ex works	26 2 6	26 12 6	22 15 0
Ex merchants' stock ...	27 2 6	28 2 6	24 5 0
2 tons and under 4 :			
Ex works	26 10 0	27 0 0	23 2 6
Ex merchants' stock ...	27 10 0	28 10 0	24 12 6
Under 2 tons to 10 cwt. ...	28 15 0	29 5 0	25 7 6
Under 10 cwt. to 5 cwt. ...	29 17 6	30 7 6	26 10 0
	Cwt.	Cwt.	Cwt.
	£ s. d.	£ s. d.	£ s. d.
Under 5 cwt. to 1 cwt.:			
To building and metal trades	1 14 4	1 15 2	1 10 5
To the public	1 18 2	1 19 1	1 13 9
Under 1 cwt.:			
To building and metal trades	0 5 6	0 0 6	0 0 5
	sheet	lb.	lb.
To the public	0 6 1	0 0 7	0 0 6
	sheet	lb.	lb.

For Scotland the above prices apply, plus zonal extras, as follow :—Zone 1, no extra; Zone 2, 2s. 6d. per ton; Zone 3, 5s.; Zone 4, 7s. 6d.; Zone 5, 10s.; Zone 6, 15s.; Zone 7, 20s. For the Isle of Wight 15s. extra per ton is payable on the prices in the above table.

For Northern Ireland prices are f.o.q. main ports and are as follows for lots of 4 tons and over, with 7s. 6d. extra for lots of under 4 tons to 2 tons. Galvanised corrugated sheets, £26 2s. 6d.; galvanised flat sheets, £26 12s. 6d.; black flat sheets, £22 15s. Prices may be increased by the amount of freight and insurance payable in excess of rates prevailing immediately prior to November 1st, 1939.

Prices of seconds and defectives must not exceed the maximum price of the corresponding specification and quantity of prime sheets.

Copper and Tin

The situation in copper has not materially altered. In Great Britain whilst consumption is heavy, supplies have been sufficient to keep the war industries fully occupied. In fact, there seems little doubt that the arrangements which have been made to obtain supplies of Empire copper are working smoothly, and that the future can be regarded with confidence. In the United States the copper position seems a little easier, and whilst it may be found difficult to obtain copper for export, rather more seems to be available than recently. The price is now called 10 c. f.a.s. The United States producers appear to be carefully supervising all export orders, and for political reasons are not anxious sellers to Japan and Russia, the two export countries which are showing the greatest interest in the market. The possibility of purchases being made by traders in one country, and the copper being subsequently being sold to Governments which are associated with the Axis Powers, does not appear to have been lost sight of. The position is further complicated as it is understood that whilst at the moment there is copper available for export, the United States Government has reserved to itself the right to take what metal it may require. It is suggested that some arrangement has been made with Chile by which a certain amount of copper will be admitted duty free to the United States for use by firms engaged on armament work. It is apparent that the United States administration is disposed to regard with disapproval any advance in the price of copper for domestic purposes above 12 c. American statistics show that the deliveries during October totalled 103,771 tons, compared with 96,485 tons in the previous month. The stocks at the end of October were 164,618 tons, compared with 185,313 tons at the end of the previous month. . . . In the tin market prices have become slightly easier. The demand from the United States has proved to be smaller than was anticipated before export licences were so freely granted in Great Britain. The Americans seem to have reserve stocks, and the pressure to buy is certainly not excessive. In the absence of any active business across the Atlantic the London market has shown a tendency to slip back. A meeting of the International Tin Committee will be held on November 26th, but it is not expected that the Committee will do more than review the situation, possibly with a view to finding out whether any countries have under-exported. If this is found to be the case there may be some readjustment of export quotas as between countries.

Lead and Spelter

The lead position in Great Britain continues satisfactory. The Empire production is considerable, and supplies are coming forward with regularity. A large proportion of the arrivals pass at once to firms engaged upon war work. The cable makers in particular are busy, and good quantities are passing into consumption at the battery works. Manufacturers of lead products, however, report that the requirements of builders are still poor. The American market remains firm, and stocks are at a low level; in fact, it is understood that there is not more than three months' supply in reserve, which is a somewhat unusual position. The price has been steady at 5.80 c., New York. . . . There seems a world-wide tightness in the position of spelter, the exception being Germany, where, as a result of her over-running of neighbouring countries, the supply of this non-ferrous metal is better than any other. The tight conditions in the United States have given rise to the suggestion that greater smelter capacity is desirable, and there has been talk of a long-term programme to expand the American industry. In Great Britain the supplies are fairly good, but the position is more stringent than in the case of other metals, and spelter is snapped up immediately it arrives. The producers' stocks in the United States are calculated at 22,600 short tons, or about two weeks' supply at the present rate of consumption.

SCIENCE AND ITS APPLICATION.—During the past year Mr. W. M. Selvey has been the Acting President of the Institute of Fuel consequent on the absence abroad of Lieut.-Colonel J. H. M. Greenly. To make the opening of the 1940–41 session, Mr. Selvey prepared an address which was not delivered owing to enemy action. In the course of his speech Mr. Selvey pointed out that the pure scientists evolved theories and hypotheses with great ingenuity, which marvellous evolution of knowledge was open to all workers in all nations. The implications of that knowledge belonged to the realm of philosophy, but the practical applications to the realm of technology. It was generally twenty years, and often longer, before scientific knowledge produced practical applications which entered into the common life of the community. These applications might be for good or the reverse, and of late years there had been much heart-searching among the pure scientists as to whether they were morally justified in increasing physical knowledge to be put to dangerous uses. The solution of the problem did not seem to be along the lines of smothering the scientists, or putting the technologists on the dole, but rather in considering what sort of men should ultimately compose that small inner coterie existing in every country which had the power and responsibility of putting great forces into action. It was an amazing state of affairs that in a world which was fast becoming wholly technical, the men having the power and responsibility could almost boast of their ignorance on technical questions. Yet there were countries where the men in real power were technically trained as a basis for their future activities, educated to some degree in the scholastic field of knowledge, but totally devoid of morals when acting as functionaries of the State.

Notes and Memoranda

Rail and Road

AN INTER-AMERICAN ROAD.—The U.S.A. Export Import Bank has loaned 4,600,000 dollars to Costa Rica to improve the Costa Rican section of the Inter-American highway. At present, of the 350 miles in the Costa Rican section of the highway, only about 60 miles is passable in all weather.

PRIVATE WAGON MISHAPS.—According to Railway Clearing House records, there has been a considerable increase in the number of hot axle-boxes on privately owned wagons and an investigation shows that in the case of grease boxes the most prevalent cause is the presence of grit and unsatisfactory lubrication generally. Attention is directed to the necessity of grease used in the boxes being in accordance with the R.C.H. Standard Specification.

RAILWAYS IN CALCUTTA.—Mr. B. M. Staig, Financial Commissioner of Railways, and Mr. J. H. F. Raper, Member, Railway Board, recently visited Calcutta to discuss with the railways there the works programme for 1941–42. The improvement of transport facilities in Calcutta is urgent, and the proposals include the installation of colour light signalling between Kalighat and the docks. This would expedite the heavy traffic passing over this bottleneck.

ROAD KERBS.—A white-faced concrete kerb which reflects light and is distinctly visible to night drivers in both wet and dry weather has been developed in New Jersey. It consists of a sloping concrete kerb faced with about 1in. of white mortar, the surface of which is scored to form sawtooth-shaped serrations, the vertical faces of which face towards the oncoming traffic. In principle the surface as a whole consists of a series of small reflecting surfaces which lie approximately perpendicular to the headlight rays.

A BRIDGE RECORD.—Canadian railway engineers have been celebrating in the appropriate journals the completion and erection of four heavy pre-cast reinforced concrete sections, each weighing approximately 135 tons, for a subway on the Canadian National Railways at Val Royal Station in Montreal, Que. Not only did the work involve the pre-casting and placing of concrete slabs of what is believed to be a record weight, but it established a remarkable speed of assembly—only four working hours for the actual erection of the units. An earlier structure of only 35ft. clear opening had become entirely inadequate to carry the heavy traffic, especially on week-ends and holidays. To overcome the congestion a plan to replace this subway by one in conformity with the 66ft. width of the highway was agreed upon by the C.N.R. and the Quebec Department of Roads.

SALVAGE ON THE GREAT WESTERN RAILWAY.—As the result of recent investigations into salvage problems on the Great Western Railway, measures have been taken to ensure the maximum recovery of all scrap materials so as to make them available for the nation's war effort. The procedure for the recovery of scrap by the large engineering departments was already well defined, but special steps have been taken to make sure that no single item capable of further use is overlooked. The discovery and collection of the numerous odd bits of waste materials which accumulate on the company's premises in all parts of its system, however, needed altogether different treatment, particularly as many materials formerly regarded as rubbish, of no commercial value, have assumed a new significance in the war economy. The whole of the staff of approximately 100,000 will constitute a salvage corps whose members will, under the inspiration of local salvage leaders, and as part of their ordinary duties, see that all waste materials which come under their notice are collected and deposited in properly appointed places. Dumping grounds are being provided at suitable points, giving separate accommodation for (1) iron and steel, brass, &c.; (2) sacking and rags; (3) tins, &c.; (4) miscellaneous scrap. At small stations a mixed dump will suffice. To clear the accumulation of scrap special salvage vans are being provided to make regular calls, say, once a month, at all the principal stations and proceed, when loaded, to the nearest stores depot—of which there are five—for resorting and disposal of the contents. Each van is fitted with four separate bins suitably lettered to receive the different descriptions of salvage.

Air and Water

CANADA DRILLING FOR OIL.—Sixteen areas in the Province of Alberta have initiated an effort to find additional oilfields in Western Canada. Arrangements have been made, or are being made, to increase storage facilities, and the Dominion Oil Controller has promised that the greatest possible use shall be made of all available Canadian oil resources. Much interest attaches to the drilling now in progress on the Commotion Creek structure in the Peace River District of British Columbia.

POWER FROM THE OHIO.—The project intended to develop hydro-electric power on the Ohio River has met with the disapproval of Army engineers. Col. E. H. Marks, division engineer, notified the interested parties that the proposed construction of high-level dams with hydro-electric equipment near Greenup, Ky., and Letart, W. Va., plus installation of the equipment on the huge roller dam at Gallipolis, Ohio, had been reported unfavourably, principally on the grounds that there is no evidence of sufficient benefits to justify the expenditures involved.

A NEW WIND TUNNEL.—To facilitate research work in an up-to-date aircraft factory, the Lockheed interests in the U.S.A. have a wind tunnel under construction which will be capable of speeds up to 260 m.p.h. The test section will be 12ft. by 8ft., enlarging to 20ft. by 30ft. at other parts of the air passages. The tunnel is of reinforced concrete and will be housed in a building 170ft. by 70ft. Power is provided by a six-bladed airscrew driven by a 1500 H.P. motor. To aid in design a model was first made to a scale of one-eighth. A 40 H.P. motor was used to drive the airscrew, and power was measured by a torque dynamometer. The model will be used later as a small tunnel for test work.

GERMAN SHIPS FOR ARGENTINA.—A company has been formed at Buenos Aires, styled the Compania Argentina de Navegacion Lloyd Argentino Sociedad Anonima, in order to purchase three German merchant ships, the "Lahn," "Anatolia" and "Nienburg," which have been laid up in the port since the outbreak of war. The new company, says the *Shipbuilding World*, proposes to approach the British Embassy to obtain recognition for the flying of the Argentine flag by the German steamers, which, under the new names of "Buenos Aires," "Rosario" and "Santa Fé," are intended for service between Brazilian and Chilean ports.

CANADIAN EXTENSIONS.—Construction of a new hydro-electric plant at Carillon on the Ottawa River, to cost 20 million dollars, is under consideration by the Ontario Government and the Ontario Hydro-Electric Power Commission. Surveys of the site, about 40 miles from Cornwall, have been completed and engineers have estimated 400,000 H.P. could be developed there within two years. Construction of the plant hinges, however, on the decision reached by the Canadian and United States Governments with regard to the St. Lawrence waterways and power projects. Another 5 million dollar plant to generate 100,000 H.P. on the Madawaska River is planned. Contracts have already been let for the 10,000 H.P. plant on the Musquash River.

Miscellanea

COFFEE FOR PLASTICS.—The first factory for plastics production from surplus coffee is being built in the State of São Paulo, and will use about 3000 bags of coffee monthly.

COAL-TAR PRODUCTS.—The Secretary for Mines, having decided to institute Government control of the primary products of tar distillation, has appointed Major T. Knowles, vice-chairman of Monsanto Chemicals, Ltd., to be Controller.

TANTALITE FROM UGANDA.—News has been published of the discovery of a deposit of tantalite near the Jemubi River, which is being worked by the Bysia Syndicate. The tantalite is of unusually high grade and equivalent to the best Australian material. Moreover, it is almost free from tin.

SCRAP.—The Railings for Scrap campaign was inaugurated in May, since when 424 local authorities have sent 22,000 tons of wrought and cast iron scrap to the steel works. In addition, 547 councils are now surveying all available railings on their property, or are considering reports of surveys in committee.

A NEW CARTEL.—An iron and steel cartel has been established in Belgium. The Syndicat Belge de L'Acier (Sybelac) has been established, to include all Belgian iron and steel works in close co-operation with the German iron and steel cartel. All export business goes through the new cartel and is being distributed by a new proportion between Germany and Belgium. The Luxembourgian steel works are outside and are to enter the German cartel.

THE N.Y. WORLD'S FAIR.—The closing of the New York World's Fair has been quickly followed by plans for the demolition of the buildings and the clearing of the site. Fourteen firms submitted bids on the demolition of the fifty-nine buildings, and the lowest offer was 148,000 dollars for the entire eight zones into which the fair grounds had been divided for the purpose of bidding. The highest bid was 550,000 dollars. The Fair corporation has thirty days in which to act, and the work must be completed in four months.

JAPAN AND RUBBER.—It is suggested in Tokyo that the I. G. Farbenindustrie A.-G. may soon grant licences for the use of their "Buna" and allied synthetic rubber patents in Japan. A plant for the purpose will, it is reported, be built in Manchukuo under the management of the Manchuria Electro-Chemical Industrial Corporation. In the meantime, stimulated by the subsidies granted under the recently enacted Organic Synthetic Chemical Industry Law, the manufacture of synthetic rubber by alternative processes is being developed.

A NEW TECHNICAL ASSOCIATION.—Gas Producer Association, Ltd., was registered last month as a public company limited by guarantee. Its objects are to encourage the use of indigenous fuels for internal combustion engines, &c. The subscribers are: C. S. Gardner, Sentinel Waggon Works, Ltd., Shrewsbury; A. B. Walters, Palm Works, Acton, W.3; J. Rusby, 300, Nimrod Road, S.E.27; G. F. Fry, Norman Road, Greenwich, S.E.10; R. J. Fleming, 25, High Street, Stony Stratford; D. J. David, Worldburn Products, Ltd., Treforest, Glamorgan; J. P. Spencer, 43, Clapham Crescent, S.W.4.

A SEMI-JUBILEE.—It is twenty-five years since the Broken Hill Proprietary began steel making at Newcastle, N.S.W., but one has to go back more than half a century to find the first event in the train of circumstances which culminated in the founding of the Newcastle Steel Works. Behind everything lies the Proprietary's silver mine at Broken Hill, N.S.W. The finding of that treasure house of silver led to the formation of the Broken Hill Proprietary Company, Ltd., in 1885. How the company was led to take up iron is too long to tell here, but in 1897 Mr. Alex. Stewart, then general manager of the Broken Hill Proprietary mine, sent Mr. R. D. Hale, his assayer at the mine, to peg out claims at Iron Knob and Iron Monarch. The pegging of those claims made possible the company's entry into steel manufacture some sixteen years later. A year later, Mr. Stewart was able to report to head office in Melbourne that iron ore with a ferrous content up to 68·5 per cent. had been mined. There was neither sulphur nor phosphorus, but residues useful for fluxing. The leases were officially issued by the Commissioner of Crown Lands in September, 1899, and in 1900. Then the working of the deposits began with delivery to the smelting plant at Port Pirie, but it was not until 1914 that the swamps at Newcastle were reclaimed and a year later before the first open-hearth furnace was tapped.

Personal and Business

MR. J. C. PATTESON, European Manager of the Canadian Pacific Railway, has been lent by his company to become Controller General of Transportation to the Ministry of Supply.

MR. ROBERT S. JOHNSON has been elected chairman of Cammell Laird and Co., Ltd., Birkenhead, in succession to Mr. W. L. Hichens, retaining the position of managing director.

MR. WILLIAM A. HANLEY, a director of Eli Lilly and Co., Indianapolis, and head of its engineering division, has been elected President of the American Society of Mechanical Engineers. He will take office during the annual meeting of the Society to be held in New York in December.

MACROME.—Extensions have been made by Macrome, Ltd., Hay Mills, Birmingham. A Glasgow branch has been opened at 27, Oswald Street, and another at 62, Market Street, Manchester. Arrangements are now being made for representation abroad, and de Pelichet, McLeod and Co. have been appointed as New Zealand agents.

MR. J. BARTLE HASTINGS has been appointed general manager of the Southampton, Isle of Wight and South of England Royal Mail Steam Packet Company, Ltd. (Red Funnel Line), in succession to the late Mr. Cyril Sharp. Mr. Hastings, who has been acting as general manager since Mr. Sharp's death, is a member of Southampton Harbour Board.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, Dec. 9th.—Technical College, Bradford. "Impact and Notched Bar Testing," C. N. Waterhouse. 7.15 p.m.

Chemical Engineering Group

Tuesday, Dec. 10th.—Burlington House, Piccadilly, W.1. Discussion on "The Salvage of Waste Materials in the Chemical Industry," to be opened by Dr. A. B. Manning. 2.30 p.m.

Glasgow University Engineering Society

Thursday, Nov. 28th.—James Watt Engineering Laboratories, Glasgow University. "Rectification of Wearing and Repair to Mechanical Parts of a Locomotive," J. S. Scott. 7 p.m.

Illuminating Engineering Society

Tuesday, Dec. 10th.—E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. Demonstrations on "Effects of Contrast in Illuminating Engineering." 2.30 p.m.

Institution of Automobile Engineers

Tuesday, Nov. 26th.—BIRMINGHAM CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham. "Notes on Filtration and Distribution of Lubricating Oil," T. C. Worth. 7 p.m.

Friday, Nov. 29th.—BIRMINGHAM GRADUATES: James Watt Memorial Institute, Great Charles Street, Birmingham. "Balancing in Automobile Engineering," G. D. Campbell. 7 p.m.

Institution of Civil Engineers

Saturday, Nov. 23rd.—YORKSHIRE ASSOC.: Hotel Metropole, Leeds. "Modern Methods of Excavation Work at Home and Abroad," W. Barnes. 2.30 p.m.

Institution of Electrical Engineers

Tuesday, Nov. 26th.—SCOTTISH CENTRE: Royal Technical College, George Street, Glasgow. "Potentiometer Calibration of Sub-standard Instruments," J. S. Tait. 6.15 p.m.

Wednesday, Nov. 27th.—S. MIDLAND STUDENTS: Watt Memorial Institute, Great Charles Street, Birmingham. Discussion, "Modern Methods of Industrial Drives." 6.30 p.m.

Institution of Engineers-in-Charge

Saturday, Nov. 23rd.—Magnet House, Kingsway, W.C.2. "Lighting in Industrial Establishments Under War Conditions," R. O. Ackerley. 2 p.m.

Junior Institution of Engineers

Saturday, Nov. 30th.—39, Victoria Street, S.W.1. "Tide Mills in England and Wales," R. Wailes. 2.30 p.m.

Manchester Association of Engineers

Saturday, Nov. 23rd.—Engineers' Club, Albert Square, Manchester. "Line Production of Machine Tools," O. Rendell. 2.30 p.m.

Saturday, Dec. 14th.—Engineers' Club, Albert Square, Manchester. "Some Experiences in Organising the Design and Manufacture of Small Engineering Apparatus," G. A. Cheetham. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Nov. 29th.—Mining Institute, Newcastle-upon-Tyne. "Mechanical Gearing for Large Power Transmission," L. M. Douglas. 6 p.m.

Royal Institution of Great Britain

Monday, Dec. 2nd.—21, Albemarle Street, W.1. General meeting. 3.30 p.m.

Tuesday, Dec. 3rd.—21, Albemarle Street, W.1. "The Physics of Air Raids," J. D. Bernal. 2.30 p.m.

Royal Society of Arts

Wednesday, Dec. 4th.—John Adam Street, Adelphi, W.C.2. "Problems of Building Reconstruction," D. E. E. Gibson. 1.45 p.m.